VA PREVIEW

Nuclear Power

IE JOURNAL OF BRITISH NUCLEAR ENGINEERING

The latest slant on fuel sheathing

Fuel cans in a variety of forms are one outlet for nuclear metals produced by I.C.I. Metals Division — aluminium and magnesium alloys, zirconium, niobium, vanadium and beryllium.

first in nuclear metals

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ICI METALS DIVISION

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NUCLEAR POWER

Many processes involve moving or compressing gases, transferring heat from one fluid to another, or cleaning gases.

Whatever the requirements may be, Howden, specialists in the design and manufacture of the necessary equipment, are confident of their ability to meet them.

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JAMES HOWDEN & COMPANY LIMITED
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15, GROSVENOR PLACE, LONDON, S.W.1.

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Edison Tele-Voice?

introduced first by 'EDISON'

Edison Tele-Voice saves money and time—it increases production and efficiency

Simplicity is absolutely necessary in a dictating instrument and the Edison TELE-VOICEWRITER affords it in full measure. Each TELE-VOICE station is a familiar 'phone-like instrument which is handled just like a telephone. Merely by pressing a button the Executive can record his work, listen back and make corrections in his dictation.

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the EDISON TELE-WRITER

Nuclear Power

THE JOURNAL OF BRITISH NUCLEAR ENGINEERING

SEPTEMBER 1958 VOLUME 3 NUMBER 29

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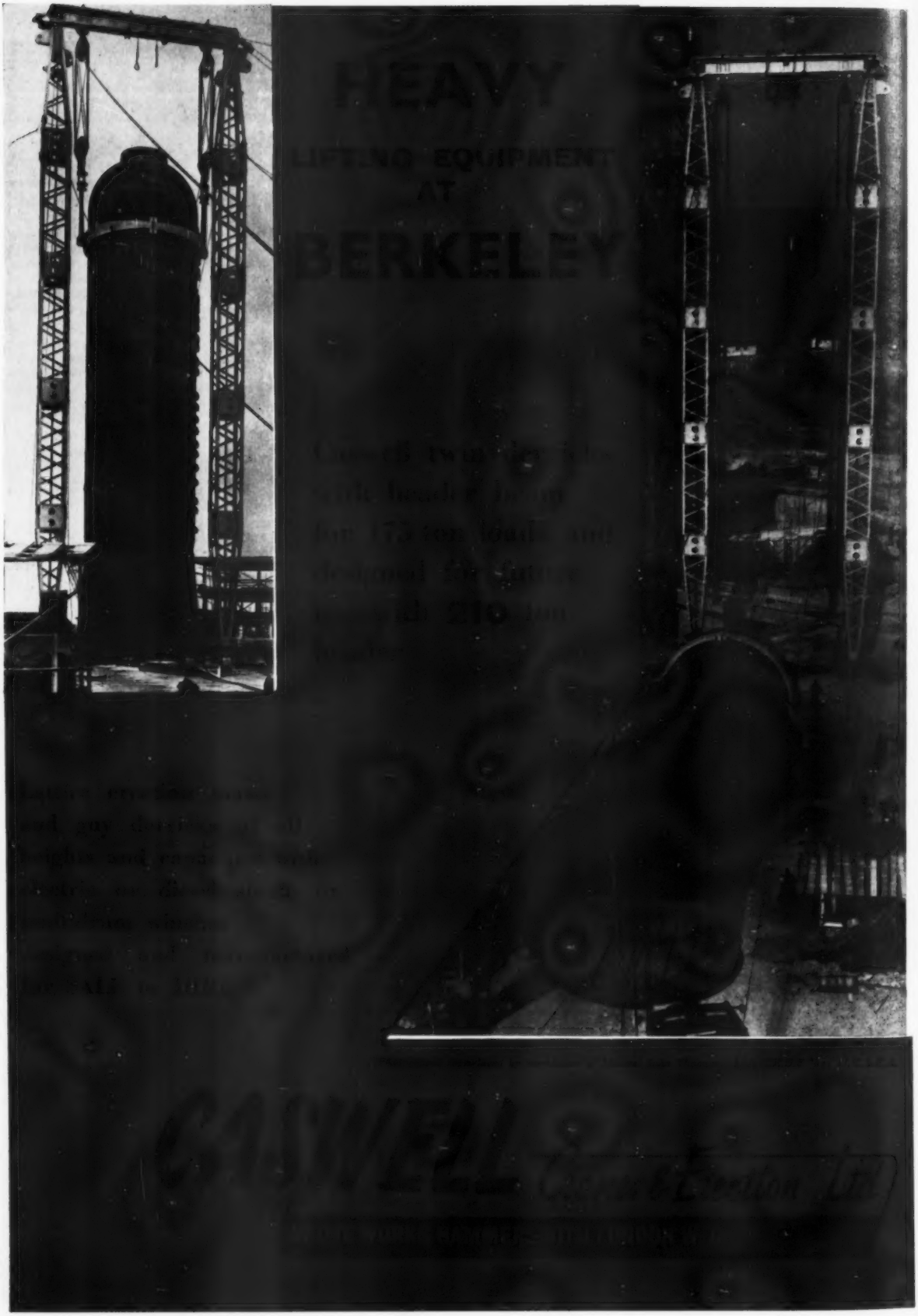
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LIFTING EQUIPMENT
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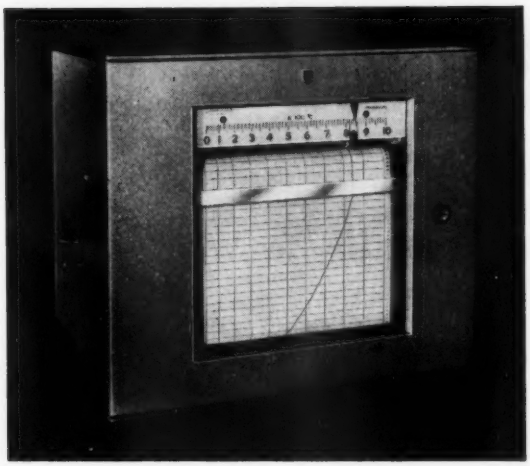
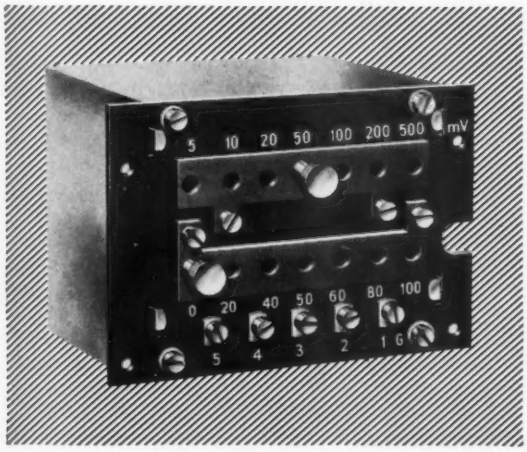


Easy to change the measuring range in this potentiometric recorder

by PHILIPS



Range-changing unit. Top rail *permits choice of seven measuring spans from 0-5 mV upwards.* Bottom rail *provides seven zero-point positions up to 100% full scale. Clear, visible indication always.*

Effectively widening the scope of millivolt instruments when employed for experimental work, Philips potentiometric recorders can be supplied with a range-changing unit with provision for no fewer than *forty-nine* measuring ranges! The range is changed *instrument fashion* merely by re-positioning a knurled thumb screw. And you can do this as often as you wish for there are no wander-leads and there is nothing to be soldered. This is only *one* of the many reasons why, point-for-point, Philips potentiometric recorders and recorder-controllers compare so favourably and why too, they are both praised and prized by the most experienced users. From a comprehensive range there is an instrument to meet every need. We invite you to write for fully descriptive literature.

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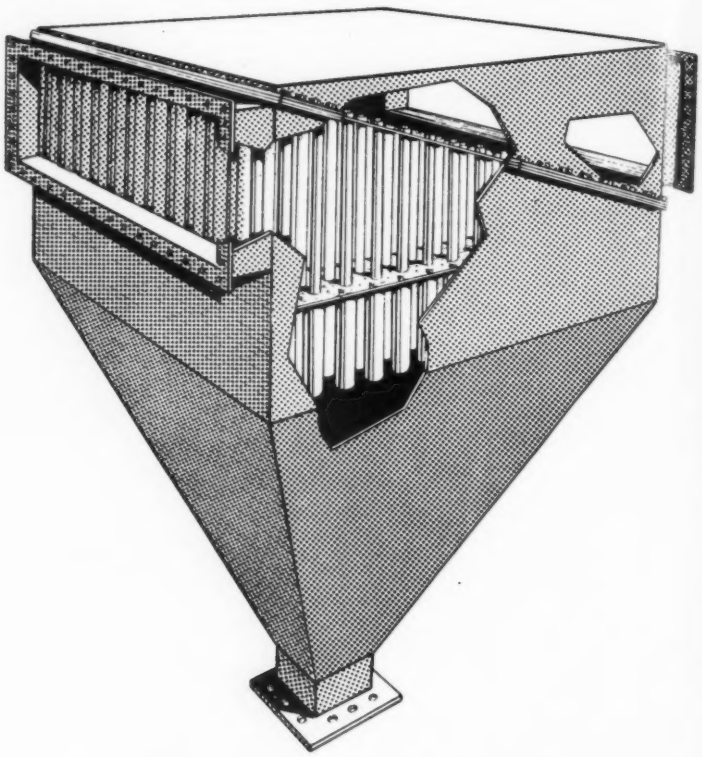
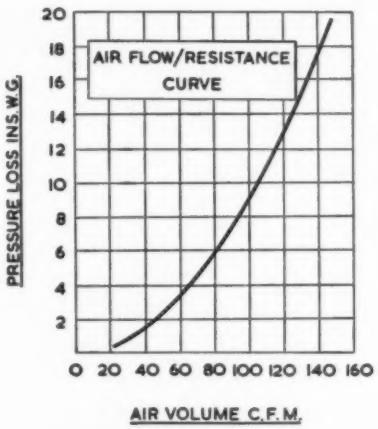
(RCL0380)

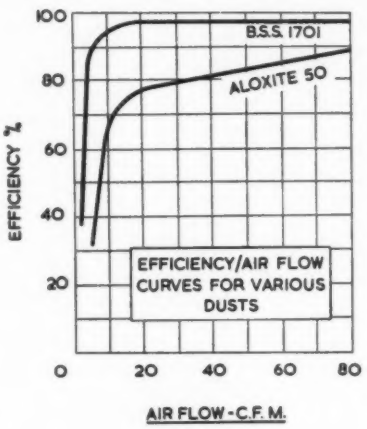
Vokes reverse flow multi-cyclone Dust Collectors

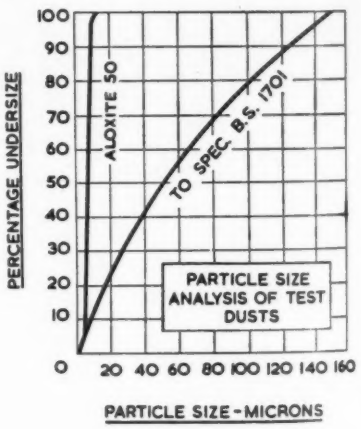


Efficient dust-collection and suppression presents many problems, particularly in the lower micron range. Now, extensive Cyclone research by Vokes' engineers has effected a radical reduction in vortex instability and bounce. The Vokes Cyclone with the 'pencil stabiliser' (patents pending) shows outstanding improvements over conventional types. We invite your dust collection and suppression enquiries.

PERFORMANCE CURVES OF VOKES MULTIPLE CYCLONE UNITS






ALOXITE 50
TO SPEC. B.S. 1701
PARTICLE SIZE ANALYSIS OF TEST DUSTS
PERCENTAGE UNDERSIZE
0 10 20 30 40 50 60 70 80 90 100
0 20 40 60 80 100 120 140 160
PARTICLE SIZE - MICRONS

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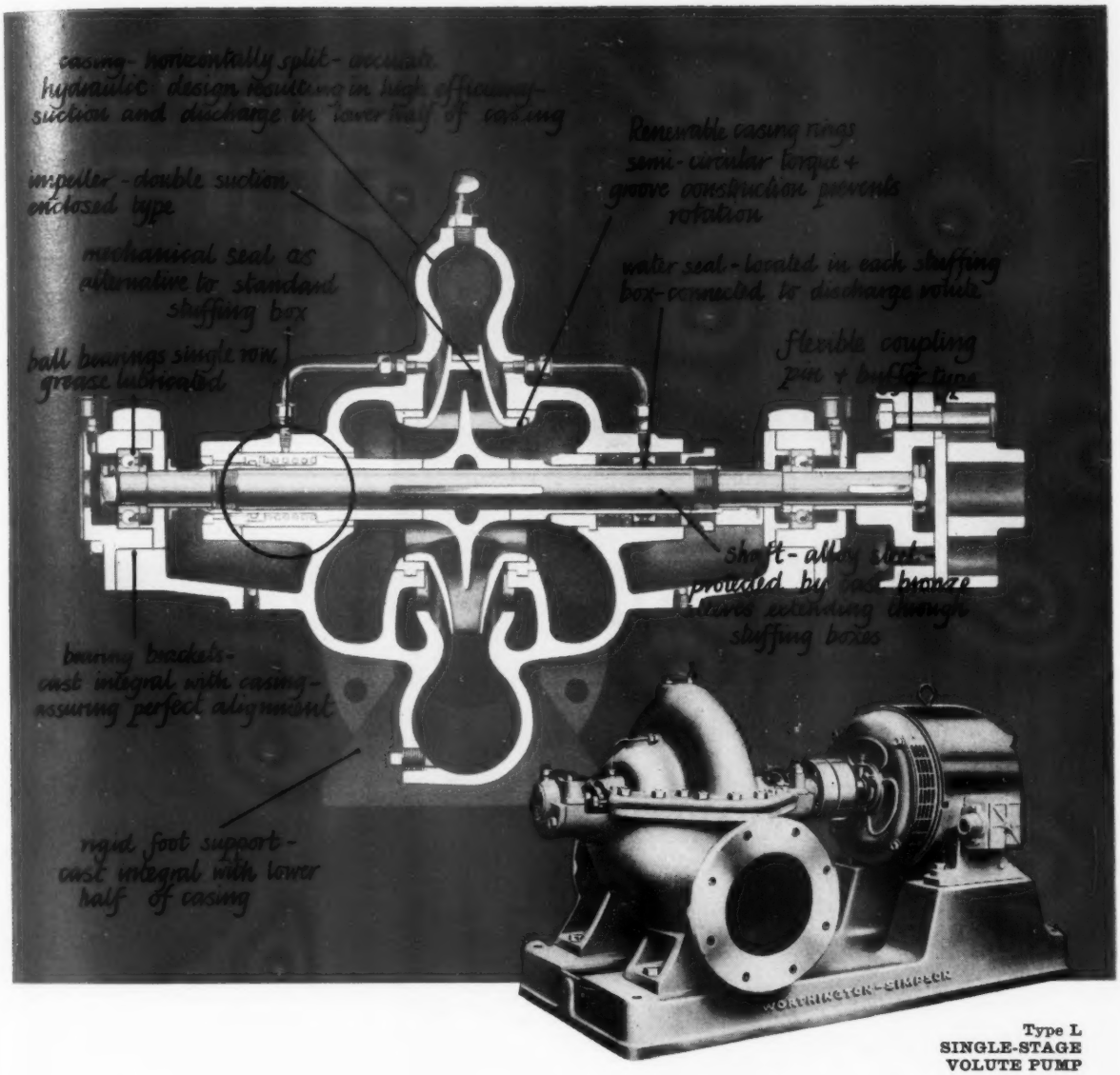
casing - horizontally split - accurate hydraulic design resulting in high efficiency - suction and discharge in lower half of casing
impeller - double suction enclosed type
mechanical seal as alternative to standard stuffing box
ball bearings single row grease lubricated
bearing brackets - cast integral with casing - assuring perfect alignment
rigid foot support - cast integral with lower half of casing
Renewable casing rings semi-circular torque + groove construction prevents rotation
water seal - located in each stuffing box - connected to discharge volute
flexible coupling pin + buffer type
WORTHINGTON-SIMPSON

Type L
SINGLE-STAGE
VOLUTE PUMP

easy access to the interior

Worthington-Simpson single and two-stage horizontal split-casing centrifugal pumps are available in capacities from 15 to 15,000 G.P.M., heads up to 550 feet depending upon capacity. Suction and discharge nozzles are integral with the lower half of the pump, and the upper half can be removed without disturbing shaft alignment or connections. These pumps will operate in series with any type of drive and are particularly suitable for applications where high efficiency and low maintenance costs are required.

Worthington - Simpson Ltd NEWARK NOTTS

P688

A machine shop specially established for machining graphite under "Clean Conditions" is now in operation at our Hayes Works. This new department supplements our already extensive facilities for machining commercial graphite and is fully equipped with specialised plant for high precision work. It is capable of producing all types of graphite components for nuclear purposes.

GRAPHITE MACHINING

These photographs show the graphite for the NATURAL URANIUM GRAPHITE MODERATED EXPONENTIAL EXPERIMENT at Imperial College, London being machined in the new department. Further facilities for precision machining of full production quantities under "Clean Conditions" are now being installed.

Powell Duffryn

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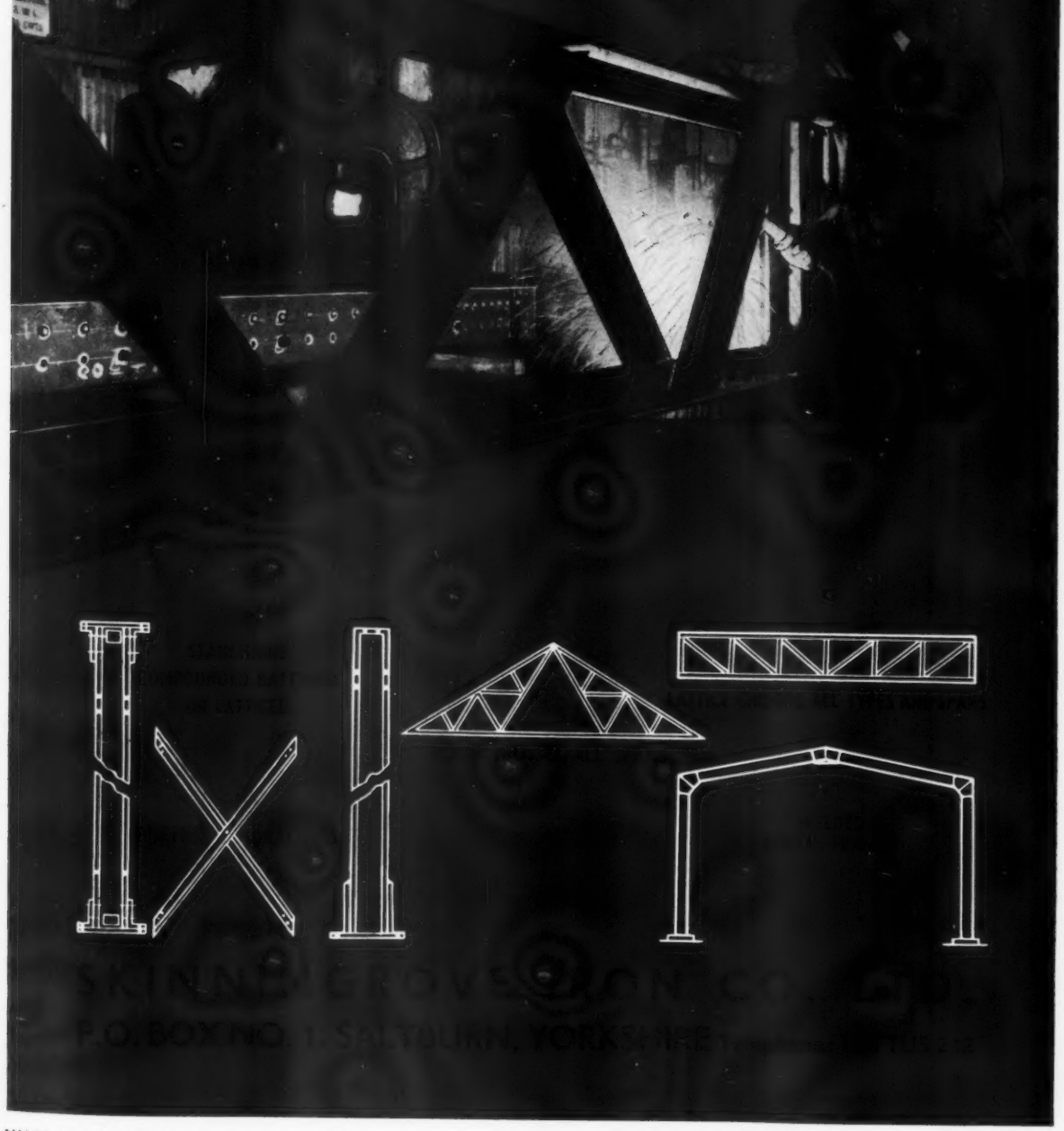


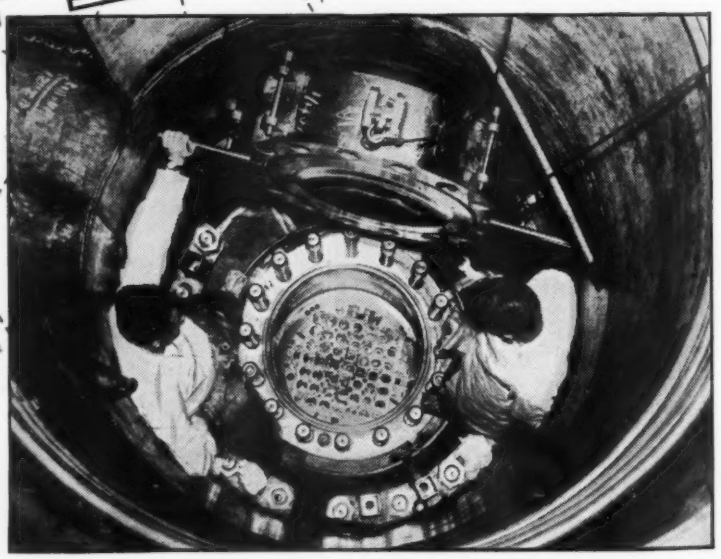
competitive power FROM THE atom

APPR-1

The APPR-1 has generated over 10 million kWh in its first year of operation, in spite of being operated on a training programme which required frequent start-up and shut-down procedures.

This is a prototype of the ALCO pressurized water reactor for which Humphreys & Glasgow Limited hold world marketing rights outside the North American Continent. ALCO's experience in the nuclear field has been underlined by their recently receiving another contract to supply for the U.S. Army a reactor having twice the output of the APPR-1.

Employing this nuclear experience, Humphreys & Glasgow Limited will be pleased to quote for nuclear power generation in the range 2 MW—20 MW electrical output (or comparable thermal outputs), employing manufacturers who will be able to give the most satisfactory products at competitive prices.



Overhead view of core structure in APPR-1 Reactor as technicians make final installation. Note 7 x 7 grid, with corners missing, that provides space for fuel elements and control rods.

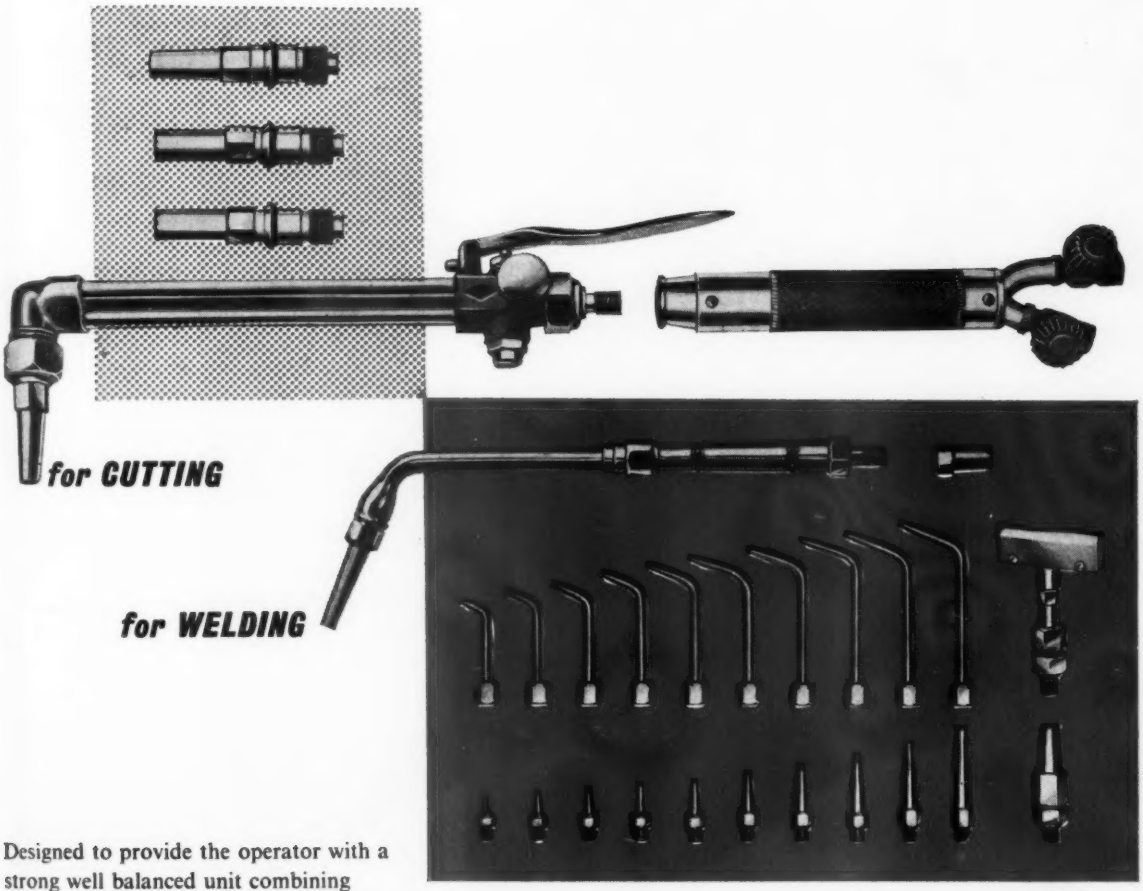
Humphreys & Glasgow Limited will be represented on the Stand of Alco Products Incorporated at the Geneva Exhibition from 1st — 13th September

HUMPHREYS & GLASGOW LTD LONDON

in association with ALCO PRODUCTS INCORPORATED, NEW YORK

maintaining ***B.I.G.*** *excellence*

COMBINED WELDING AND CUTTING BLOWPIPE



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for WELDING

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Nozzle mixing of gas which is best deterrent to flashback

One-piece solid copper nozzle

Special high pressure oxygen seats

HARRIS DESIGN

... and built to ***B.I.G.*** *standards*

NRP 1801

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Sales and Technical Assistance available in most areas

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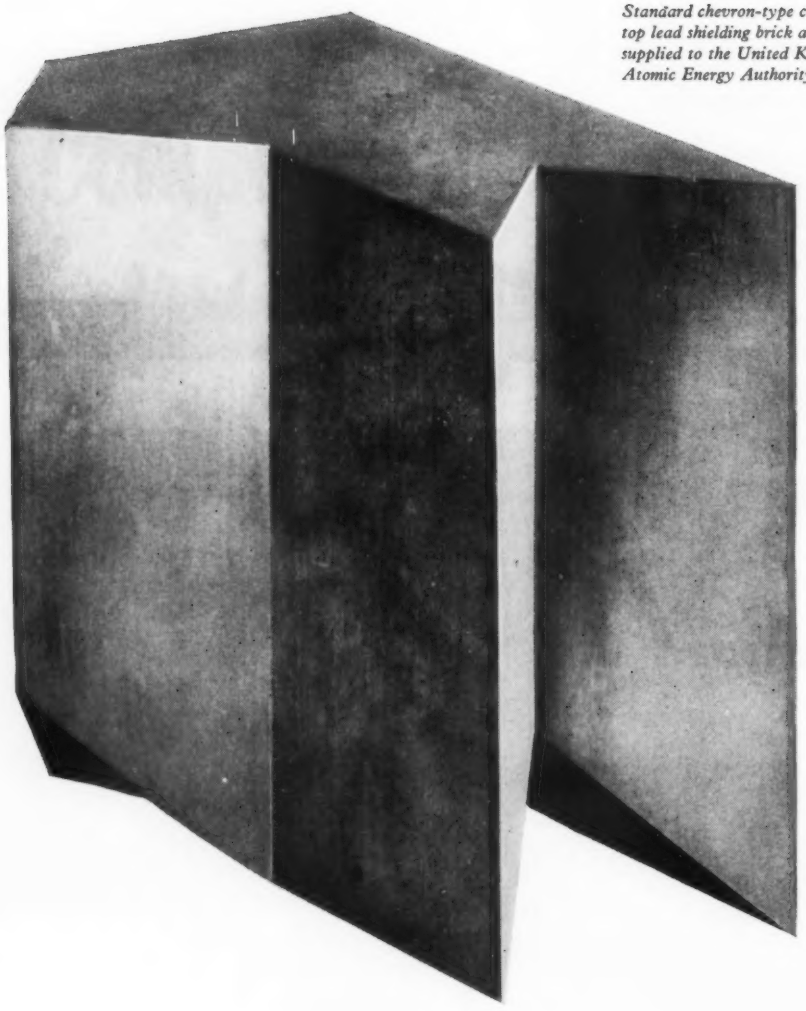
Standard chevron-type corner top lead shielding brick as supplied to the United Kingdom Atomic Energy Authority.



Where lead is vital for shielding against radiation the people to consult are—

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MANUFACTURERS LIMITED

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Lead Works Lane, Chester.

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constant tension supports

FOR LOADS UP TO 8 TONS
PIPE MOVEMENTS UP TO 18″

High-pressure steam piping is subject to wide variations in temperature, which produce considerable expansion and contraction. Unless the pipe supports can absorb and compensate for this movement, severe stresses are set up which may result in fracture. The "Con-Ten" Pipe Support is designed to cradle any type of piping with constant tension under all conditions, throughout the range of movement. "Con-Ten" is installed, with eminently satisfactory results, in power stations, oil refineries, chemical and industrial plants throughout the world.

British Patent No. 474008, 720074, 720075, 697987, 65318
U.S.A. Patent No. 2129320

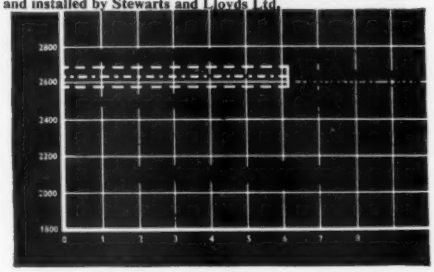
Ferrybridge 'B' Power Station, Central Electricity Generating Board, Yorkshire Division. H.P. Steam pipes supplied and installed by Stewarts and Lloyds Ltd.

Leibfried **Red Top Pipe** Supports for load from 100 to 5,000 lbs. and total travel of 3″.

Conventional type "Con-Ten" Supports for loads of up to 2 tons with a total vertical movement up to 12″.

Duplex "Con-Ten" Supports for load of up to 8 tons with a total vertical movement up to 12″. This type is acknowledged as one which produces minimum friction and kinematic variation. It has been specially designed for any applications where exceptional accuracy is demanded,

From graph it can be seen that the maximum friction is equivant to 2.17% of the applied load.



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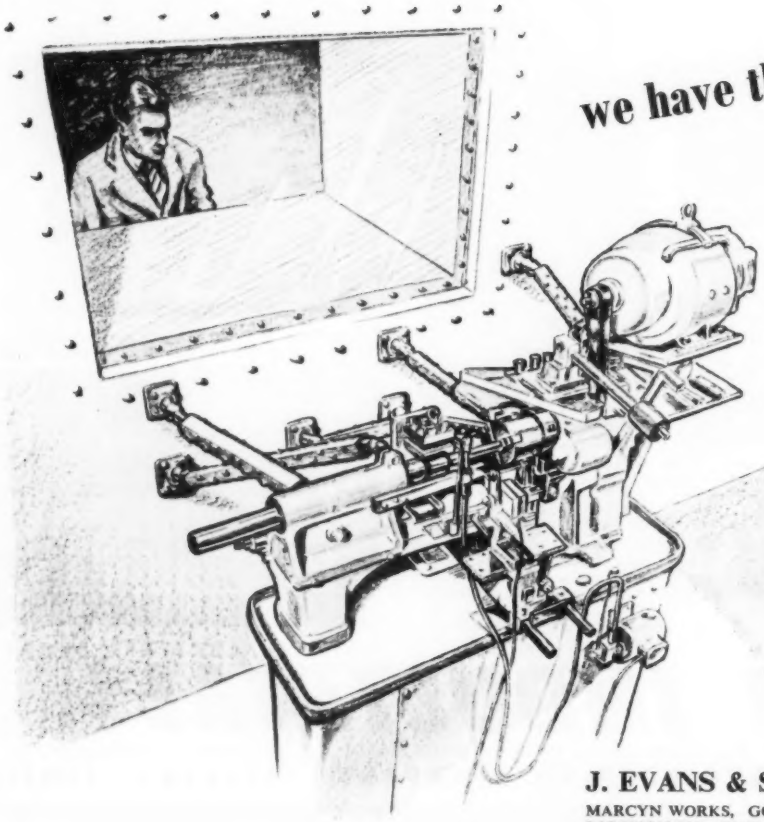
BRITISH INDUSTRIAL
ENGINEERING COMPANY (STAFFS) LIMITED

CORONATION WORKS, HAINGE ROAD, TIVIDALE, TIPTON, STAFFS.

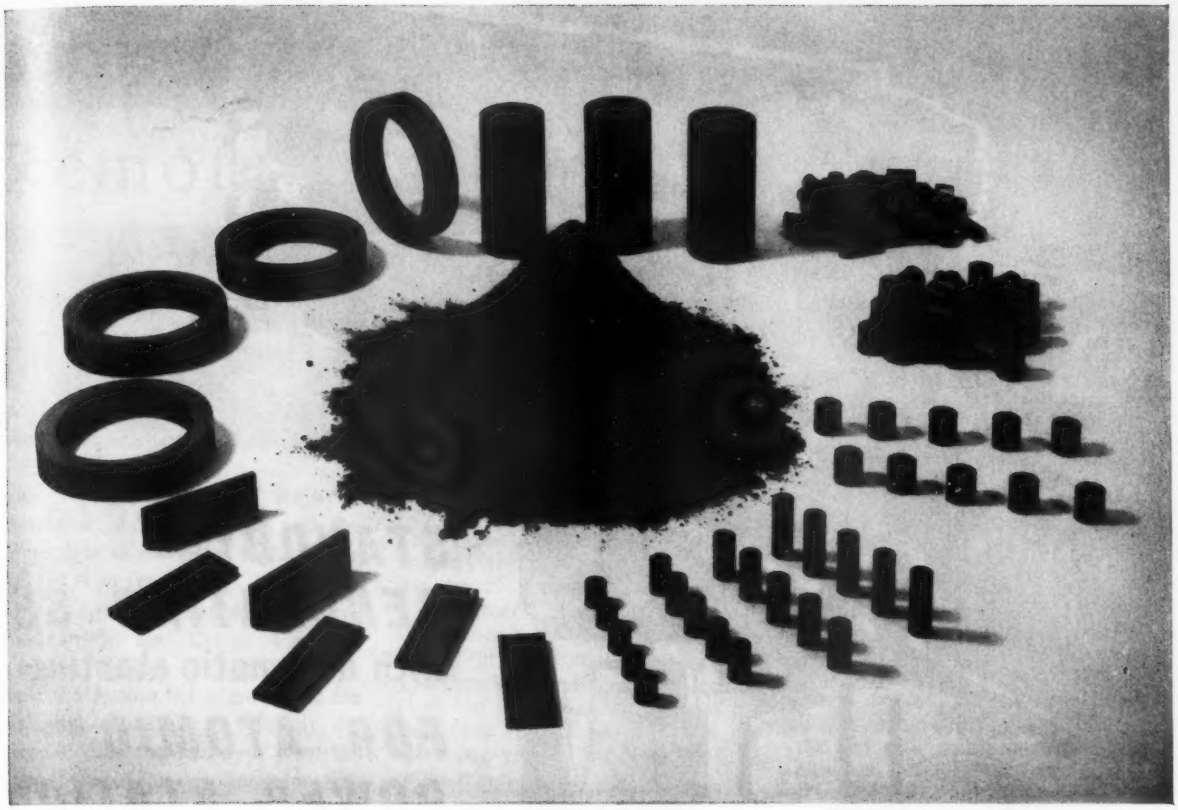
for remote-controlled machines...

We are in the unique position through our long experience as designers and builders of special purpose machinery and precision machine tools, to offer *practical* equipment for the machining and handling of radio-active materials.
One of the many special projects carried out by us is the remotely controlled lathe (illustrated below) for the machining of tensile test specimens from irradiated uranium for Dounreay fast breeder reactor. Equipment for the nuclear field can only be entrusted to people who know the problems ! Visit us in Portsmouth where selected films and a most interesting range of activities can be shown.



we have the inside story

J. EVANS & SON (PORTSMOUTH) LTD.
MARCYN WORKS, GOLDSMITH AVENUE,
PORTSMOUTH, ENGLAND. Tel. 32233.



NUMEC uranium oxides and compounds meet every nuclear fuel specification

One of the many ways in which NUMEC serves the nuclear energy industry is in the production of high purity oxides and compounds, such as UO_2, UO_3, U_3O_8, ammonium diuranate, uranyl sulfate, and uranyl fluoride, in any enrichment. Because of our advanced facilities and thoroughly experienced personnel, we can produce these materials promptly, to meet any current specifications.

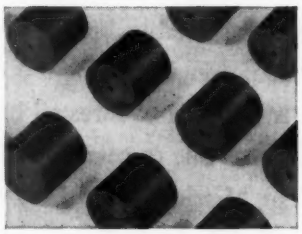
The oxides can be supplied as high-fired or sinterable powders or as finished high-density pellets, plates, rings and cylinders, held to extremely close dimensional tolerances.

NUMEC also produces uranium and thorium alloys; metallic and ceramic dispersions; control and moderating materials; special equipment such as cathodic vacuum etchers and vacuum furnaces; and many other items.

Services available to the industry include unirradiated scrap recovery; wet analytical chemistry; emission and X-ray fluorescence and diffraction spectroscopy; uranium isotopic assays; metallography; tensile, fatigue, impact, hardness and burst testing; helium mass spectrometer leak detection; high-temperature, high-pressure corrosion testing; arc and induction melting; brazing and inert gas welding.

In short, NUMEC has fully integrated chemical, ceramic, metallurgical and scrap recovery production and testing facilities—manned by personnel distinguished by their important contributions to reactor design and fabrication as well as to materials development and production.

We invite your inquiries.



The UO_2 pellets shown at the right illustrate some of the difficult fabrication problems NUMEC has solved. As sintered, density is 94%; diameter .356" ± .002"; height .356" ± .010". Each pellet contains two thermocouple holes .032" in diameter. The edge of the outer hole is .030" from the periphery of the pellet.

NUMEC

Nuclear Materials and Equipment Corporation

Apollo, Pennsylvania

Telephone: GRover 2-8411 **Cable "NUMEC"**

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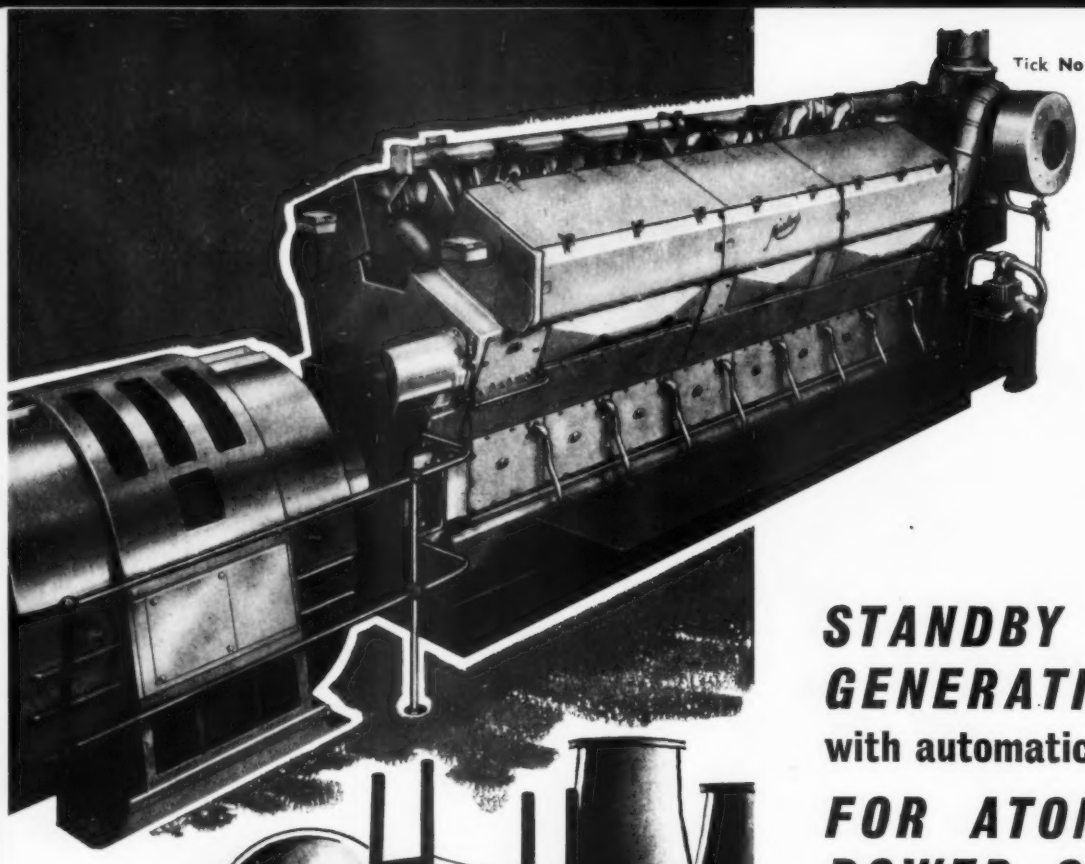

STANDBY GENERATING SETS
with automatic starting
FOR ATOMIC POWER STATIONS

Within a few seconds of receiving the starting signal and without manual attendance, these Mirrlees oil-engine sets will carry full load, providing a reliable auxiliary and standby supply for atomic power stations and other installations where it is essential to forestall breakdowns and serious loss due to cessation of mains power supply. The Mirrlees J and JV Types of engine cover a comprehensive series including 3, 4, 5, 6 and 8-cylinder in-line engines and 12 and 16-cylinder vee-form engines. All can be offered in naturally aspirated or turbocharged form, the latter with or without air aftercoolers.

Mirrlees diesels

The power range extends from the 210 BHP J3 three-cylinder naturally aspirated up to the 2272 BHP JVSS 16 sixteen-cylinder turbocharged engine with air aftercooler.

MIRRLEES, BICKERTON AND DAY LIMITED
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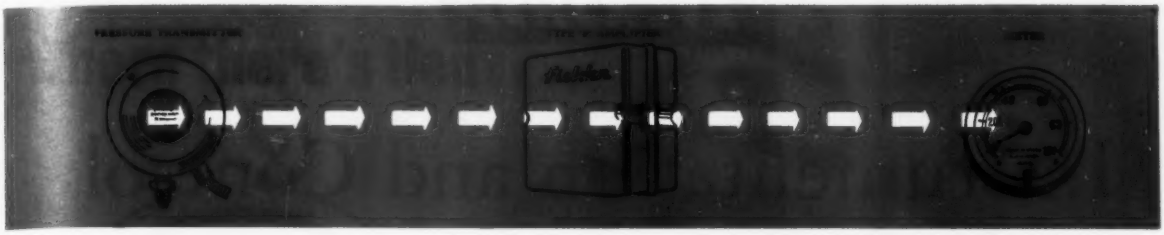
Fielden AUTOMATION

Remote Pressure Transmission

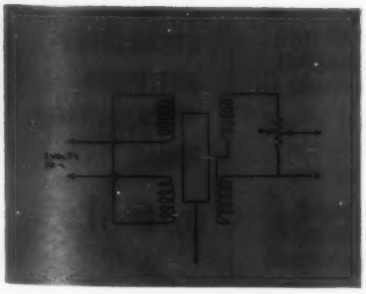


The Fielden system of Remote Indication of Pressure has all the advantages of electrical transmission and yet is so very simple.

The range of equipment covers transmitters for Gauge Pressure, Vacuum, Absolute Pressure and Differential Pressure but in each case the indicating equipment is precisely the same — an important fact from the point of view of spares and maintenance.

Principle of operation

In each Fielden Pressure Transmitter there is a small differential transformer and the output of the transformer depends upon the positioning of a ferroxcube core. This core is positioned by a bourdon tube, diaphragm or bellows depending upon the range. In order to simplify the equipment the differential transformer has been designed to operate on 50 cycles but the voltage is very low and the transformers can be handled, in operation, with perfect safety.



Type 'F' Amplifier

The Type 'F' Amplifier itself is a simple stable amplifier which accepts the signal from the Differential Transformer and amplifies it to the stage when it can be used for direct indication on a moving coil meter.

The Type 'F' Amplifier can be located close to the Transmitter or the indicating meter, whichever is the more convenient, and requires little or no maintenance.

Indicating Meters

Indicating Meters with 300 degrees scale, 6″ diameter are available as standard, but other patterns and sizes to match other instruments are available.

Schemes available

This Fielden pressure transmission system can be used for single point applications where one pressure is continuously indicated on one meter or a number of transmitters can be switched to one indicator.

Transmitters

The High Pressure and Low Pressure Transmitters are illustrated below. These are supplied with standard B.S.P. threads and are screwed into the point of measurement. Simple electrical connections are used to transmit the information to the Indicator.

Ranges

The minimum range of pressure for this equipment is 0-5″ w.g. and the maximum standard range is 0-15,000 p.s.i. although higher ranges can be covered to special order.

If you are interested in Remote indication of PRESSURE, VACUUM or FLOW, please write for further information to :—

Fielden

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Instrumentation and Control

is specified for

Nuclear Projects

because of its

Flexibility and Simplicity

EVERSHED's are supplying instrumentation equipment for the nuclear energy project at Hunterston and for the new G3 reactor in France. EVERSHED equipment has already been installed at Windscale, Aldermaston and Dounreay. These projects are but a few for which the EVERSHED electronic instrumentation equipment was specified.

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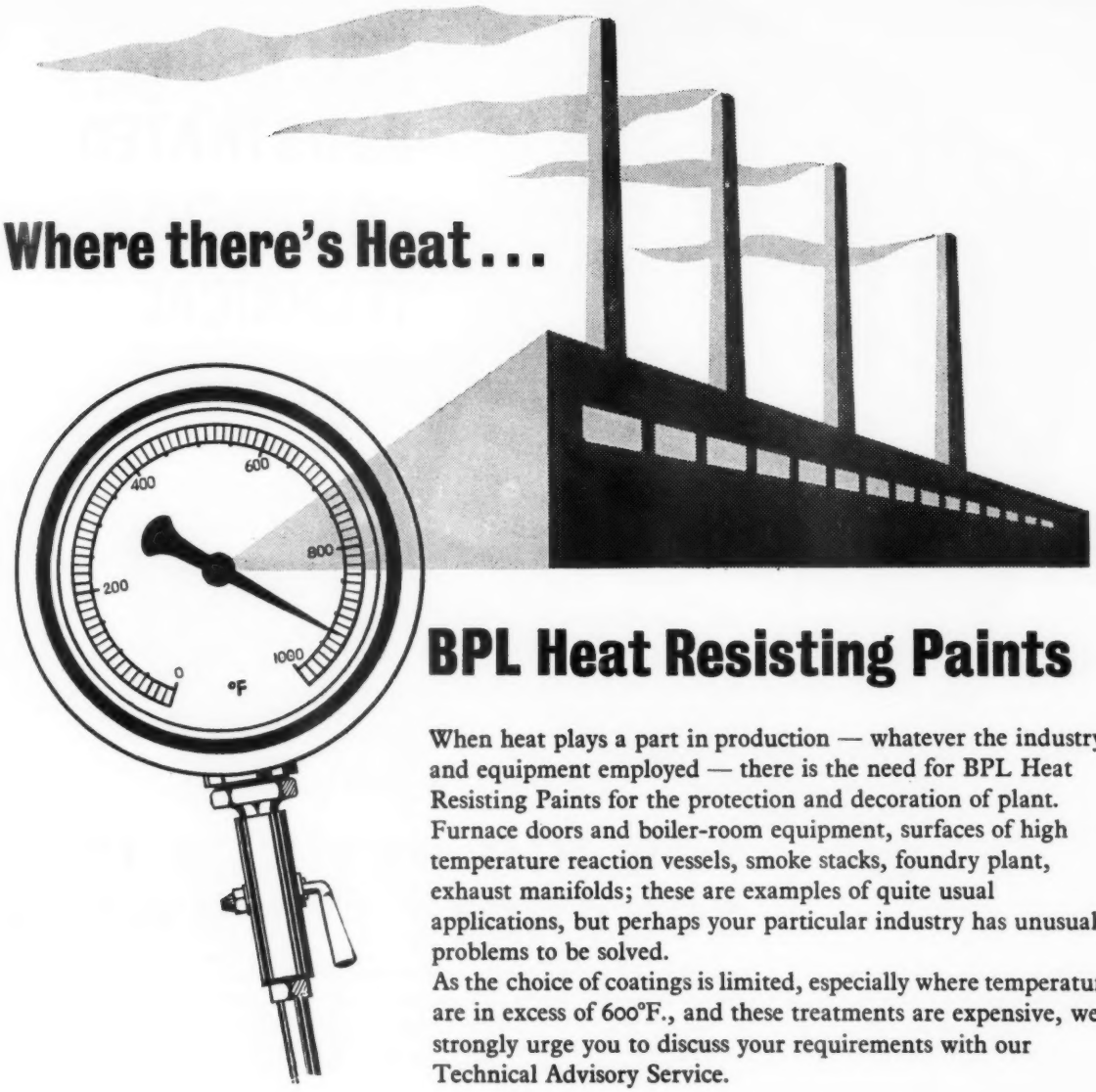
7/88N

Where there's Heat...



BPL Heat Resisting Paints

When heat plays a part in production — whatever the industry and equipment employed — there is the need for BPL Heat Resisting Paints for the protection and decoration of plant. Furnace doors and boiler-room equipment, surfaces of high temperature reaction vessels, smoke stacks, foundry plant, exhaust manifolds; these are examples of quite usual applications, but perhaps your particular industry has unusual problems to be solved.

As the choice of coatings is limited, especially where temperatures are in excess of 600°F., and these treatments are expensive, we strongly urge you to discuss your requirements with our Technical Advisory Service.

EXAMPLE TREATMENTS FROM THE COMPREHENSIVE RANGE

FINISH REQUIRED	TEMPERATURE RANGE	PRIMER	SECOND COAT	FINISHING COAT
Gloss Finish (interior or exterior)	Up to 350°F.	B.P.L. Heat Resisting Primer (M.P.34)	B.P.L. Heat Resisting Undercoat	B.P.L. Heat Resisting Enamel
Metallic Finish (interior or exterior)	Up to 400°F.	B.P.L. Heat Resisting Primer (M.P.34)	'Mettal' (Thermal) Aluminium Undercoat	'Mettal' (Thermal) Aluminium Finish
Bright Aluminium (interior only)	Up to 850°F.	'Lumeros X' Aluminium	—	'Lumeros X' Aluminium

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BPL/IM 12

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FOR BIG SAVINGS IN CONCRETE FORMWORK

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Lower the cost of raising the shuttering with RAWLTIES · RAWLOOPS · RAWLHANGERS

These popular Fixing devices are designed to facilitate the speedy erection, striking and re-erection of formwork for all types of concrete work. This is achieved by providing anchorages to which the Shuttering can be Fixed and struck easily and quickly. They have many applications in Civil Engineering and Building construction for all types of buildings and in docks, reservoirs, airports, railways, bridges, silos, power stations, harbours, dams, sewage schemes, oil refineries bunkers, water towers, etc. In fact, wherever formwork is required for concrete. They minimise the use of scaffolding and obviate the use of through bolts. They form a positive contribution towards savings in timber, steel, time and manpower, with a consequent saving in building costs. They are extremely strong, simple and adaptable.

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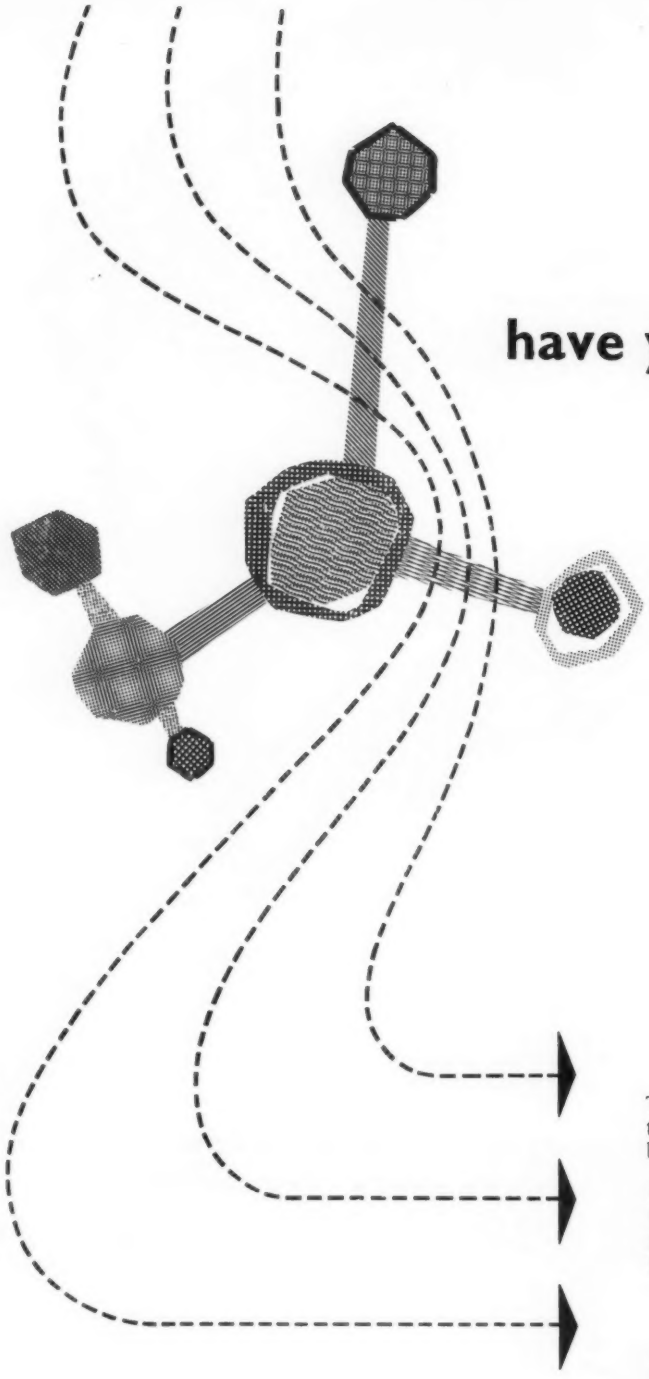
MEMBER OF THE OWEN ORGANISATION



have you a problem too?

The know-how needed to produce drop forgings to your requirements is dependent on experience backed by modern Technical resources.

If your needs are drop forgings* in special alloy, heat and creep-resisting steels or in special non-ferrous alloys, you'll solve many problems by consulting . .

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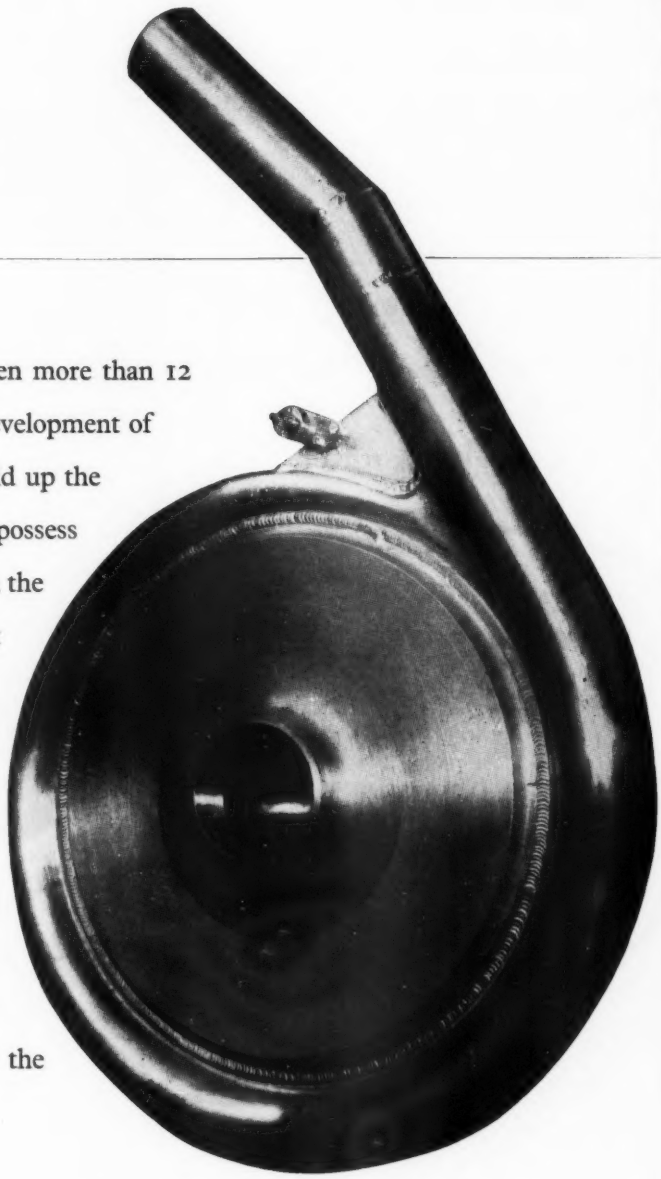
*** Drop Forgings are Stronger and Tougher**

A 16mm. Colour Film with sound commentary, entitled "Drop Forgings in Alloy Steels," is available on request.

THE FIRTH-DERIHON STAMPINGS LIMITED, SHEFFIELD.

Shaping the Future



Skill doesn't come easily. It has taken more than 12 years of close association with the development of Atomic Energy for Marstons to build up the specialized technical knowledge they possess in this field. Marston Excelsior, from the start, have been among the foremost suppliers of specialized equipment to the U.K.A.E.A. — plate type fuel elements for the research reactors Dido, Lido, and Dimple; gas coolers for Calder Hall, equipment of various kinds for ancillary plants. It is this past experience that is helping Marstons to shape the future with such precision.

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(A subsidiary of Imperial Chemical Industries Limited)

INVOLUTE COMPRESSOR CASING

(Approximate diameter 30″, overall thickness 5″) made in two half-pressings from Kynal P5, Argon Arc welded. In the centre, fully machined vanes made from aluminium castings are sandwiched between the centre plates.

MAR 234

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HAVE YOU A **NUCLEAR ENERGY** PRODUCTION PROBLEM?

For instance—
like the Transport Container illustrated here which is shielded with lead and weighs 14 tons:

or
like this fragile Graphite Spring and other components which weigh only a few grammes.

IF SO, the skill and experience of our engineers is at your service.

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Also specialists in:
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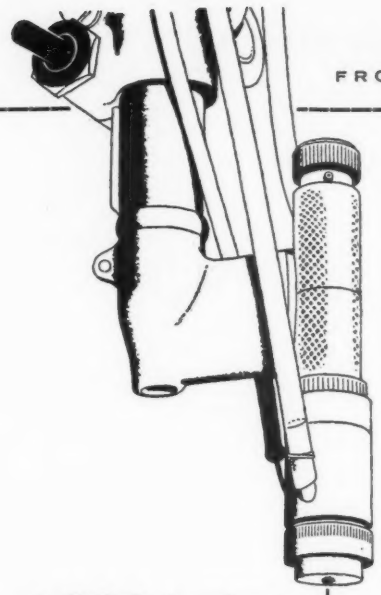
FROM BRITISH OXYGEN - FOR BRITISH INDUSTRY



NOW YOU CAN CUT ALUMINIUM

at 200 inches a minute!

The new Tungsten Arc Process, shielded by an inert gas mixed with hydrogen, makes possible cutting speeds of up to 200 inches a minute! It deals speedily and accurately with aluminium and aluminium alloys to 1" thickness; gives cuts which are clean and need very little, if any, finishing. Use it for hand cutting in all positions: machine profiling; bevelling; stack cutting; and plate edge preparation. You'll find it a real investment in production efficiency.

Write for fully illustrated literature

BRITISH OXYGEN | British Oxygen Gases Ltd., Industrial Division, Spencer House, 27 St. James's Place, London, S.W.1.

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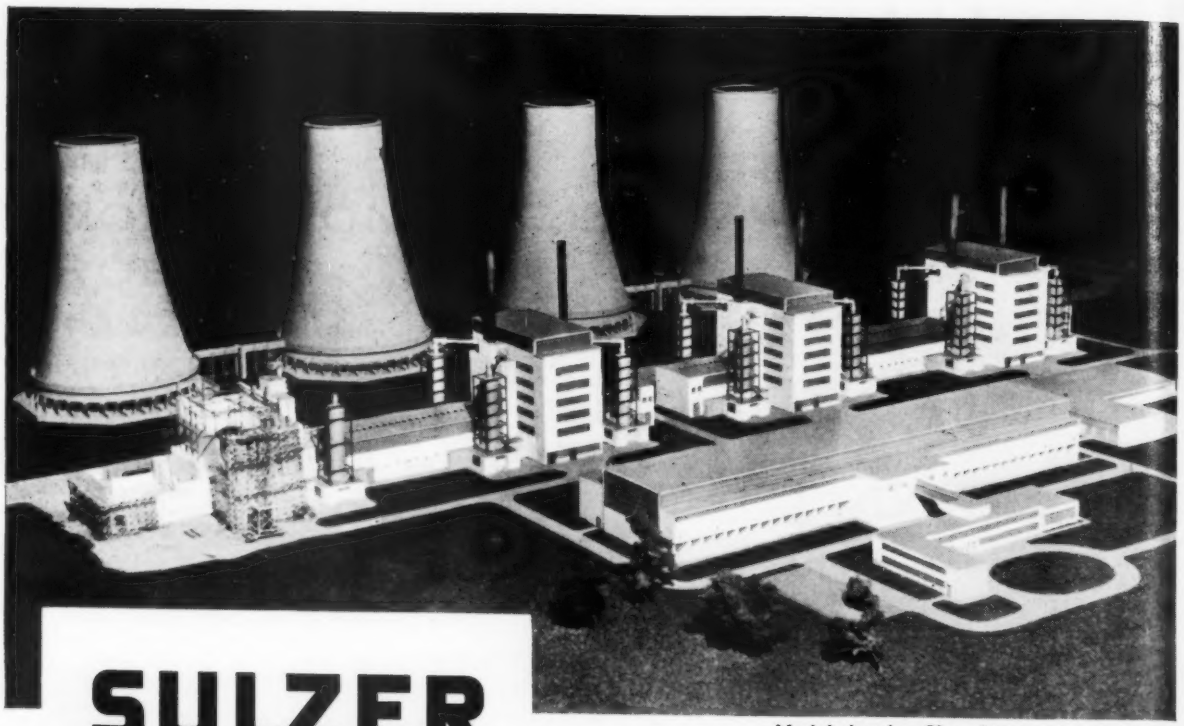
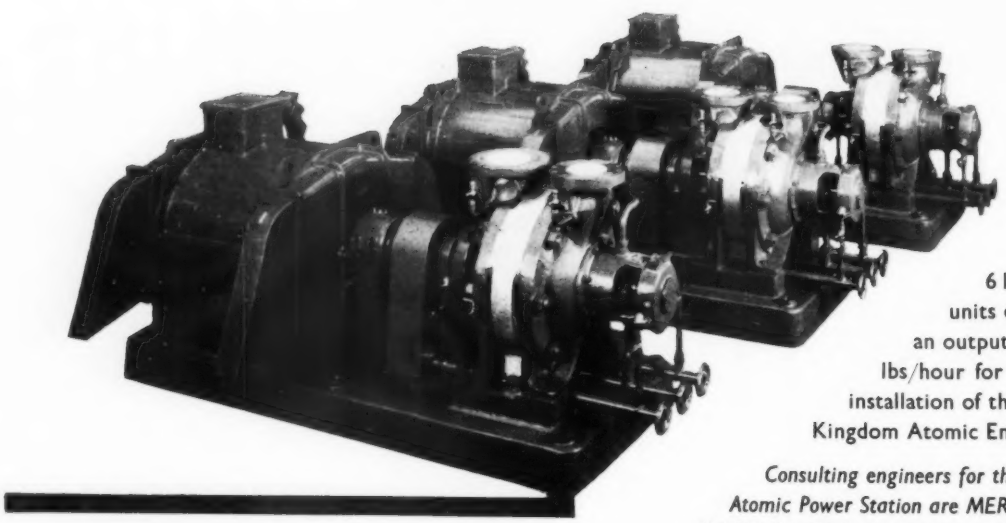


Model showing Chapelcross power station

SULZER

BOILER FEED PUMPS FOR NUCLEAR POWER STATIONS



6 low temperature units each rated for an output of 650,000 lbs/hour for the Chapelcross installation of the United Kingdom Atomic Energy Authority.

Consulting engineers for the Chapelcross Atomic Power Station are MERZ & McLELLAN. Civil engineering contractors are he MITCHELL CONSTRUCTION CO., LTD.

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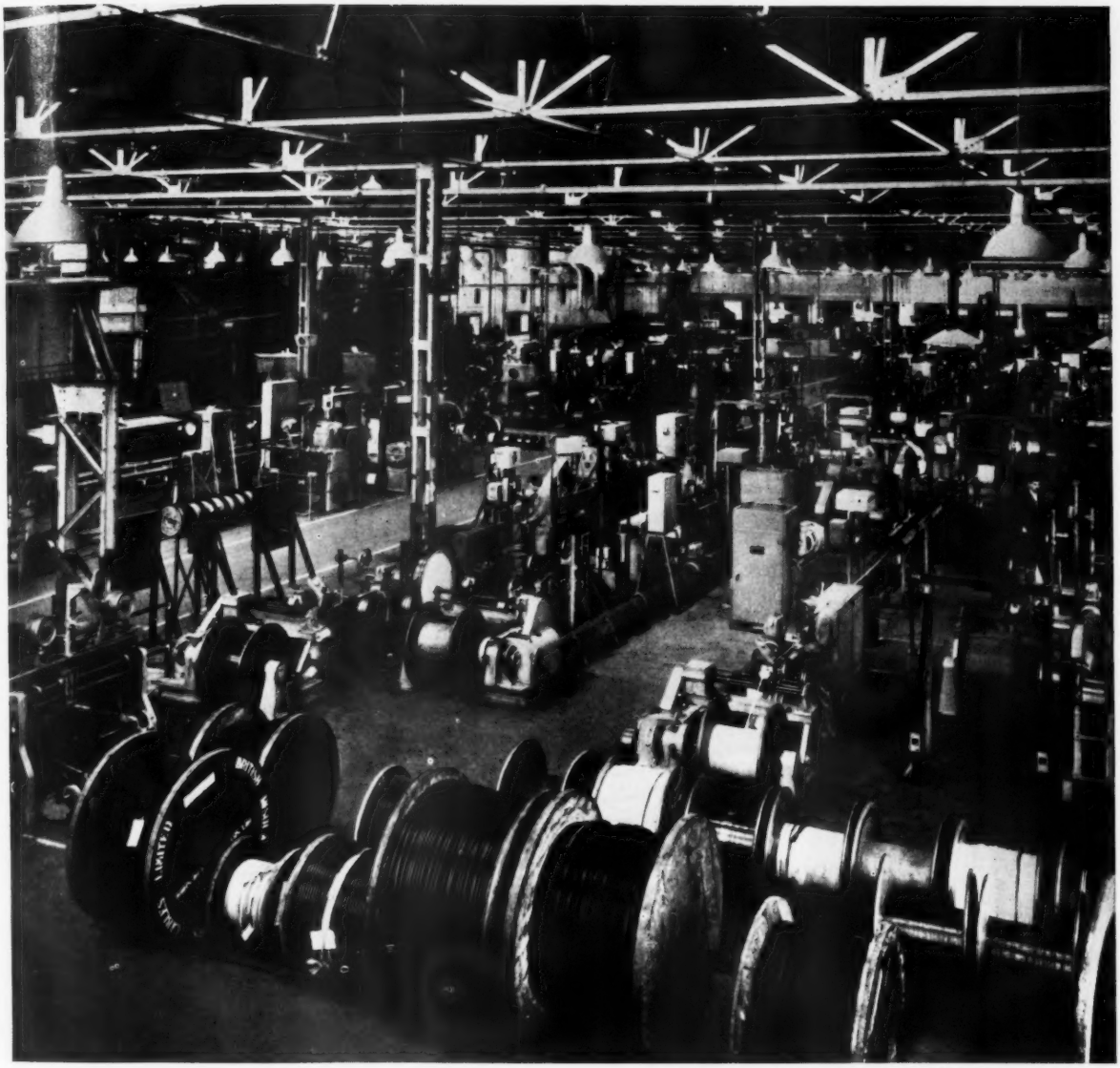

British Insulated Callender's Cables Limited : general view of the thermoplastic core extrusion shop, Helsby Works.

When BICC use p.v.c.

they choose I.C.I. 'Corvic'

I.C.I. 'CORVIC' p.v.c. polymers are backed by the finest research and technical service in the country. When you are considering the use of p.v.c.-covered wire and cable that service is at your disposal. So if you have any queries or require advice on the use and applications of p.v.c., get in touch with I.C.I.

P.V.C. has proved to be particularly efficient for insulating and sheathing cables and wiring for the building, electrical and aircraft industries. Here, British Insulated Callender's Cables Ltd., choose 'Corvic'. They could choose no better.

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'Corvic' is the registered trade mark for the p.v.c. polymers manufactured by I.C.I.

IMPERIAL CHEMICAL INDUSTRIES LIMITED · LONDON · S.W.1

PC.10

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Nuclear Power Station under construction at Berkeley, Gloucestershire.

Electricity— today's power and tomorrow's wealth

OUR COUNTRY'S ECONOMY depends on electricity; more electric power will bring higher production in the factories, greater comfort and pleasure in our everyday lives. As our economy expands, so does the need for power, and at the present rate it doubles every ten years.

Electricity from nuclear powered generating stations will play a part of ever increasing importance in meeting this steadily rising demand. Already construction work has started on three nuclear power stations with an aggregate capacity of 1,100,000 kilowatts; by 1966/67, 5 to 6 million kilowatts of nuclear energy will be available.

Not all electricity will be generated by nuclear power, however, and 'conventional' generating stations will continue to be needed. The Central Electricity Generating Board has recently placed contracts for the largest 3,000 r.p.m. turbo-alternator and associated unit boiler in the world—a 550,000 kilowatt unit for the projected new station at Thorpe Marsh. Another projected new station—Blythe 'B'—will be equipped with 275,000 kilowatt in-line units; these, too, are the biggest of their kind yet designed.

Though these are projects which will not be completed for some time, the work of the Central Electricity Generating Board is playing an important part in today's fight against inflation. Power stations are being built now at an overall cost no greater than in 1948 — £50 per kilowatt installed. And though the output capacity of the power stations has doubled since 1948, the increase in manpower is only about one-third.

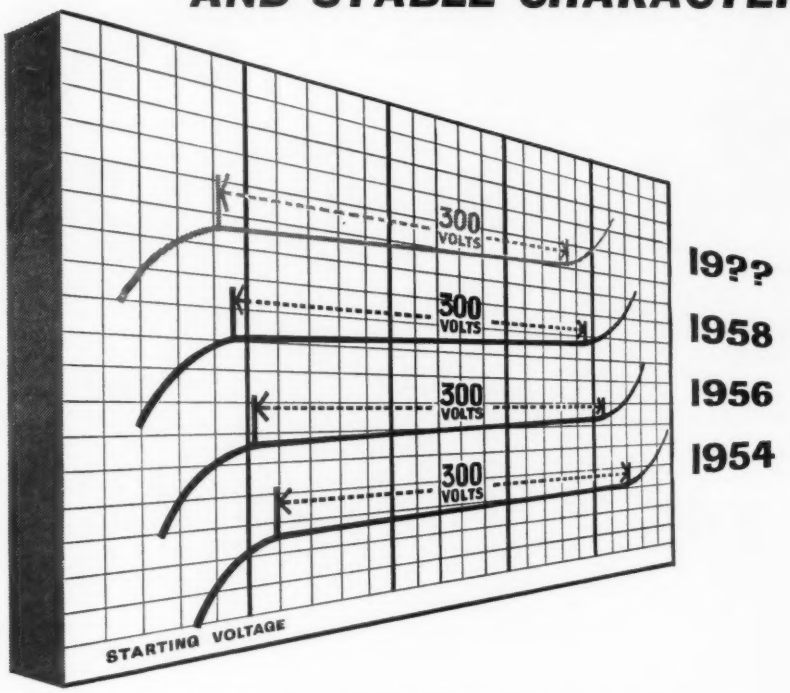
* * *

By providing today for the power we shall need in years to come, the Central Electricity Generating Board is building a secure foundation for our future expanding prosperity.

THE CENTRAL ELECTRICITY GENERATING BOARD

LONG LIFE

AND STABLE CHARACTERISTICS



Long life and stable characteristics under conditions of continuous or intermittent operation—these are the features that characterise all Mullard halogen quenched Geiger Müller Tubes.

These facts were verified by a test carried out on a tube selected at random. Operating intermittently over a few years, this tube has so far recorded a count of 4.8×10^{10}. During this period, its starting voltage has changed by only 20 volts and its plateau is still over 300 volts long (three times its specified minimum), with a slope of .03%.

Remember these characteristics when next you specify a Geiger Müller tube—order Mullard and be sure of long life.

Details of the range of Mullard Geiger Müller tubes may be obtained on application to the address below.

HALOGEN QUENCHED GEIGER MÜLLER TUBES

Mullard

X-RAY DIVISION

MULLARD LTD., X-RAY DIVISION, NEW ROAD, MITCHAM JUNCTION, SURREY Telephone MITcham 3471

MXR507

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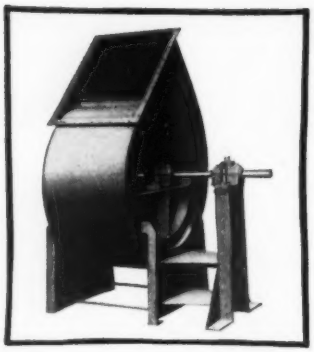
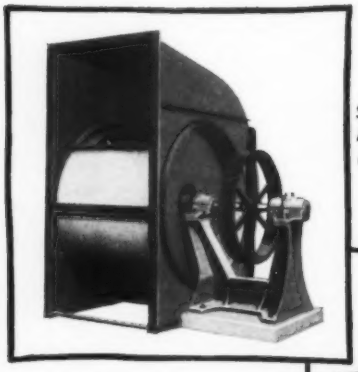
CYCLONE

FANS AND EQUIPMENT

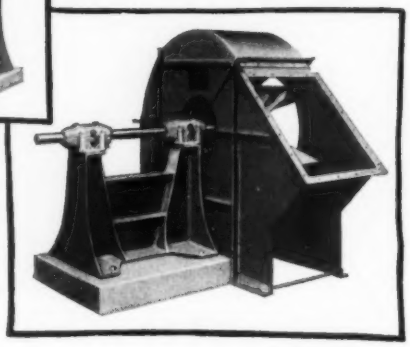


SLOW SPEED MULTIVANE FAN (Intermediate size).



SLOW SPEED MULTIVANE FAN (Large size).

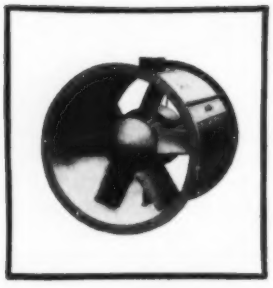
Air ways



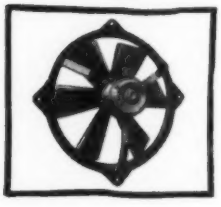
PADDLE BLADE FAN.

are

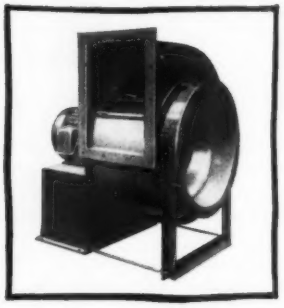
our ways



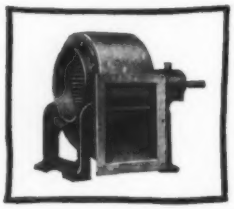
AXIAL FLOW FAN.



PROPELLER FAN.



P.V.C. FAN.



SLOW SPEED MULTIVANE FAN (Small size).

Ventilation, dust collection, fume removal and cooling industrial "hot spots" are jobs for Cyclone Fans and Allied Equipment. 75 years' experience, technical advice and comprehensive literature is yours on request.

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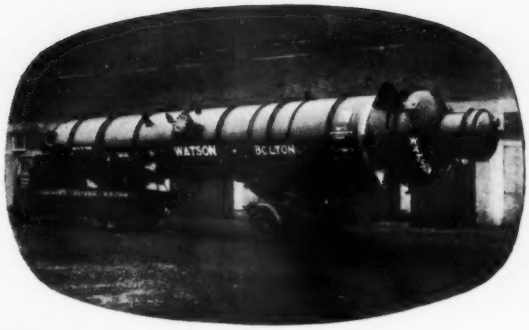
Structural Steelwork



The photograph above shows part of a 2,000 ton contract for U.K. Atomic Energy Authority, Springfields Plant, Preston

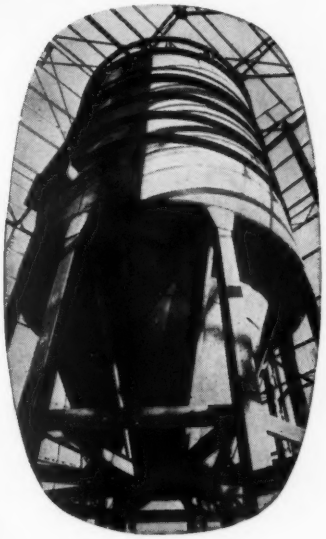
Inspection facilities include laboratory equipped with up-to-date testing machines and radiography

▲ Pressure Vessels

Vessel for Shell Petroleum Co. Ltd.
55 ft. long : 6′ 6″ dia.
To ASME Code

Welding

Site welded pyrites flash roaster casing
51 ft. Height, 23′ 6″ dia.
Weight 90 tons. ▼



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How's this for service?

ONE of the many little services given freely by Kodak is the calibration of your X-ray set and the provision of a chart showing the correct exposure for any type of work done on that particular set. By referring to this chart you can reduce trial-and-error exposures on new jobs and produce a satisfactory radiograph first time. As no two sets behave exactly alike (being affected to some degree by outside conditions, such as the local power supply) this individual treatment is rather essential.

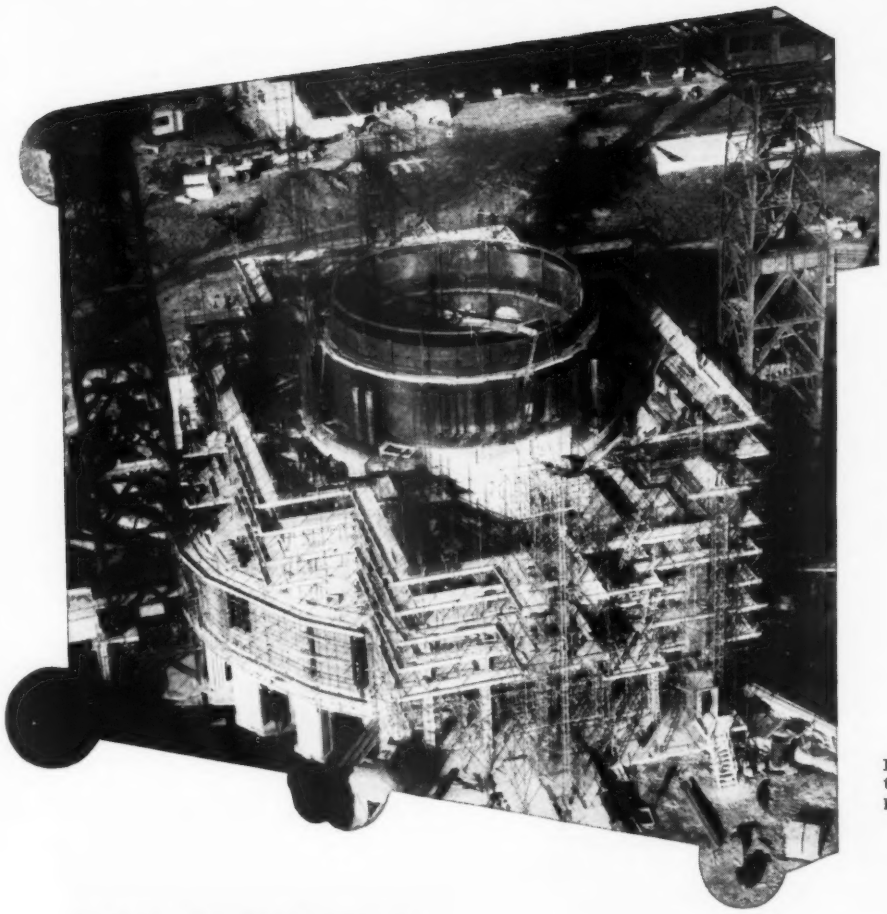
The Kodak radiographic specialist will visit your department by request and make a few trial exposures. This will take about 15 minutes and can be done during the tea break to avoid interfering with work. The chart is then drawn up to show the correct exposures for the various kinds of job and types of film.

The representative then takes his leave. There is no sales talk, no charge, no obligation, just a straightforward series of tests and the compilation of a simple chart.

If you would like our specialist to call and make up a chart to suit your X-ray set, please write in the first place to

Kodak
LIMITED

Industrial Sales Division, Kodak House, Kingsway, London, W.C.2.



Berkeley No. 1 reactor; the thermal shield in process of construction.

FOR BERKELEY

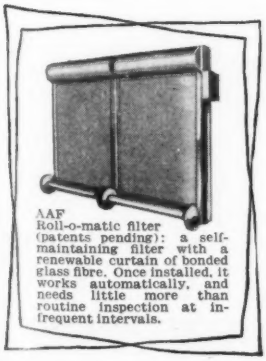
A.E.I.—JOHN THOMPSON SPECIFIED

"AIR CONTROL" FILTERS

The air used for cooling the thermal shields at Berkeley power station is filtered at all stages by equipment supplied by Air Control Installations Ltd. Banks of ACI **Dustrap** filters are mounted in the inlets; specially engineered AAF **Roll-O-Matic** filters provide the biological cleansing of air passing through the outlets.

Once again, "Air Control" filters have proved that they meet the exacting specifications demanded for nucleonic applications.

May we send you full details of our complete range?



AAF Roll-o-matic filter (patents pending): a self-maintaining filter with a renewable curtain of bonded glass fibre. Once installed, it works automatically, and needs little more than routine inspection at infrequent intervals.

AIR CONTROL

INSTALLATIONS LIMITED

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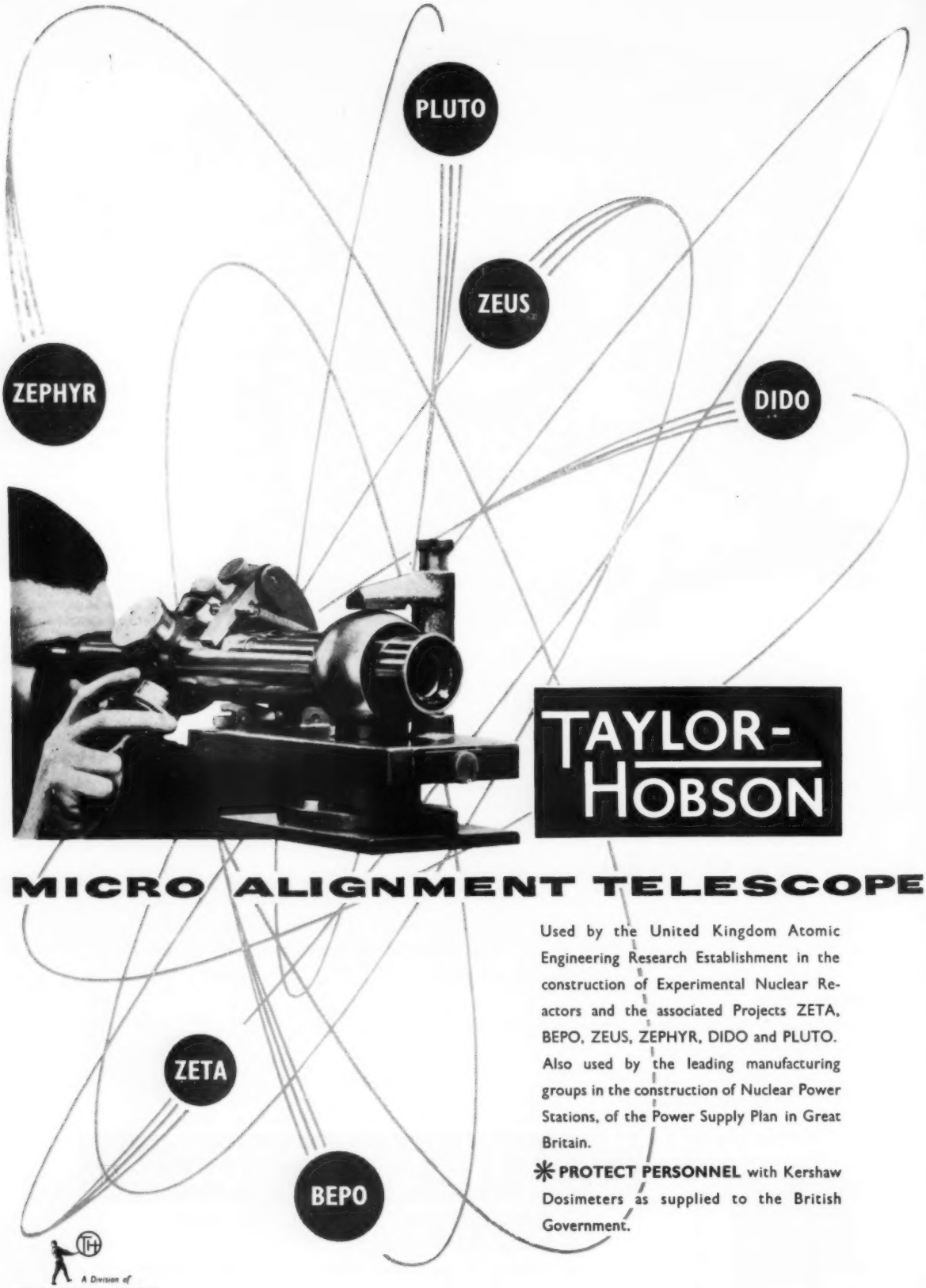

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MICRO ALIGNMENT TELESCOPE

Used by the United Kingdom Atomic Engineering Research Establishment in the construction of Experimental Nuclear Reactors and the associated Projects ZETA, BEPO, ZEUS, ZEPHYR, DIDO and PLUTO. Also used by the leading manufacturing groups in the construction of Nuclear Power Stations, of the Power Supply Plan in Great Britain.

✳ **PROTECT PERSONNEL** with Kershaw Dosimeters as supplied to the British Government.

A Division of RANK PRECISION INDUSTRIES LTD.

TAYLOR TAYLOR & HOBSON LTD., LEICESTER, ENGLAND

AT28

$$T_i = \sum_{i=1}^{n+1} a'_i \beta'_i$$

$$\sum_{i=1}^{n+1} \beta i'^{12}$$

CONFERENCE NOTES

10 am : Possible energy source 100,000 curies (radio-caesium)

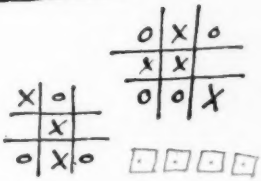
Heavy Water Reactor / 10-12 tons / 15MWS 66. burnup — means 67,500 tons (C)

Walter 26428 Rockefield

Lunch with Walter — 1230

Astoria — Tell AP

U·K·A·E·A



25% increased prod. isotopes use in POLYMERISATION ?

Gas / liquid cooled reactor (Gas mod.)

138

4365 | 6043618

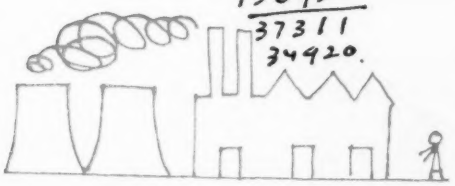
4365

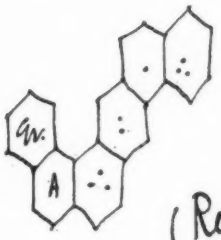
16826

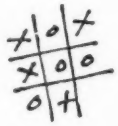
13095

37311

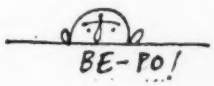
34920.





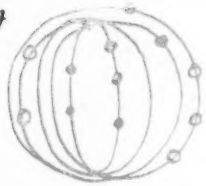


(Remember umbrella — Astoria)



Walter again — dinner ?

Anticipated output 2000 MW in '65



U235

U238

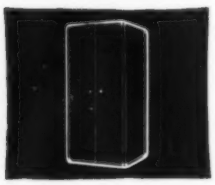
see NEWALLS re. insulation of new installation

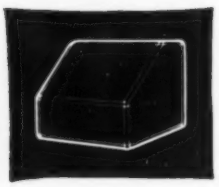
NEWALLS INSULATION CO. LTD., *Head Office:* WASHINGTON, CO. DURHAM, ENGLAND
A member of the TURNER & NEWALL ORGANISATION
Agents and vendors in most markets abroad.

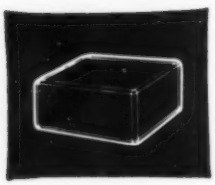
LGB

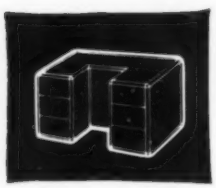
Extended range of connectors and extrusions means

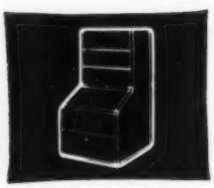
IMLOK NOW MORE VERSATILE THAN EVER!

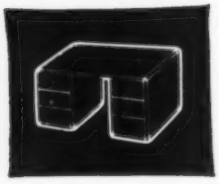












See what you can do with the unique Imlok system—*think* how it can save you money. Precision cases, cabinets, and other structures can all be quickly built to your own design—and using unskilled labour. The system is ideal for research and prototype work as well as for production runs. Various corner connectors and strong, light alloy extrusions lock together to form the framework required. Where fixed panels in the sides, top, back and base are required, they are retained in a groove in the extrusion specially designed for that purpose.

Scope for design unlimited

The Imlok extrusion is now available in five alternative strengths to suit almost every application, and the extended range of components means unlimited scope in shapes and sizes. Special jigs for quick, accurate cutting and filing also supplied. May we send more details?

IMLOK

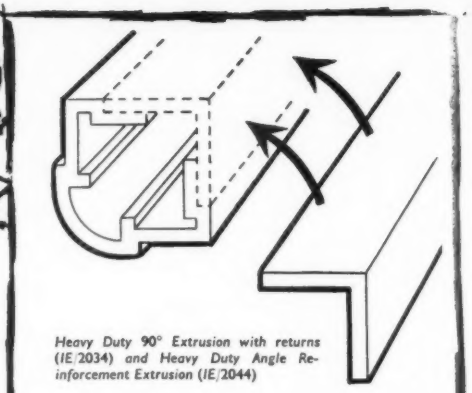
Economical, too !

The material's cost of the framework for this Heavy Duty Double Bay Rak, size 6′ x 3′ 6″ x 1′ 9″, using the Heavy Duty components illustrated, is little over £30.

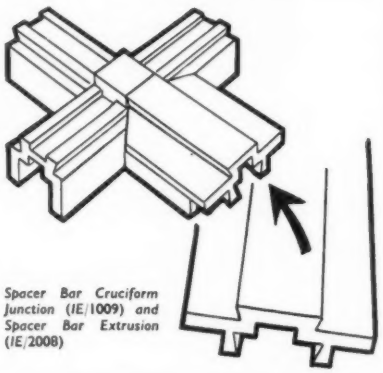
Using general duty components, i.e., IE/1001 90° Casting, IE/2024 90° strengthened Extrusion, IE/1004 Spacer Bar Casting, IE/2008 Spacer Bar Extrusion and IE/1009 Cruciform Junction, the material's cost for the framework only is just under £20.

ALFRED IMHOF LIMITED Dept. N9 Ashley Works Cowley Hill Road Uxbridge Middx. Tel: UX5-5567

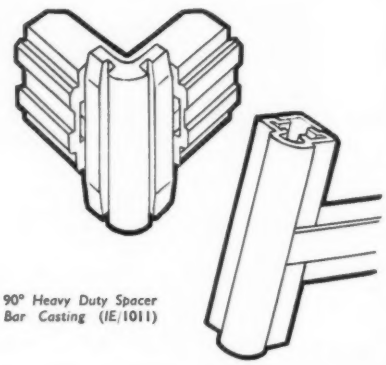
Export & London Showrooms: 112/116 New Oxford Street WC2 Tel: MUSeum 7878



Heavy Duty 90° Extrusion with returns (IE/2034) and Heavy Duty Angle Reinforcement Extrusion (IE/2044)



Spacer Bar Cruciform Junction (IE/1009) and Spacer Bar Extrusion (IE/2008)



90° Heavy Duty Spacer Bar Casting (IE/1011)

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Bailey's and Atomic Energy

1949 WINDSCALE PLUTONIUM PILES

1951 CAPENHURST DIFFUSION FACTORY

1953 CAPENHURST DIFFUSION FACTORY

1953 CALDER 'A' PRELIMINARY WORKS

1954 CALDER 'A' MAIN CONTRACT

1955 CAPENHURST DIFFUSION FACTORY

1956 CALDER 'B' MAIN CONTRACT

1957 BERKELEY NUCLEAR POWER STATION
A.E.I.-JOHN THOMPSON NUCLEAR ENERGY CO. LTD.

1957 WINDSCALE WORKS

N. G. BAILEY & CO., LTD.

Electrical Engineers

BURLEY VALE WORKS, KIRKSTALL ROAD, LEEDS, 4

Phone: LEEDS 637854

London *Persian Gulf* *Manchester*

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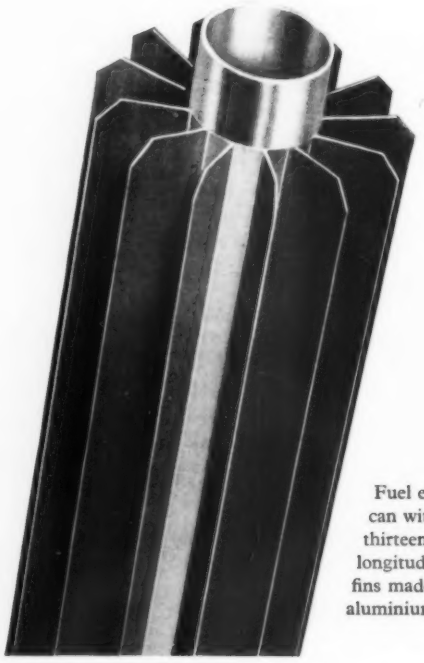
Some recent developments in manufacturing techniques and special applications of tubes in a variety of metals . . .

No. 7 OF A SERIES BY ACCLES & POLLOCK

(of particular interest to the Nuclear Power Industry)

The illustrations show examples of two different types of integrally finned fuel element cans Accles & Pollock produce for gas and water cooled reactors. The fins provide the most effective means of heat removal from the hot uranium bars which are housed in the cans.



Fuel element can with thirteen longitudinal fins made in aluminium.

Fuel element can with thirty-two fins—typical of the multi finned can made in Magnox A12 alloy for carbon dioxide cooled power reactors

Stainless Steel Tubes

Hundreds of miles of titanium stabilised seamless stainless steel tubing is being used in the Civil Nuclear Power Stations which are now under construction.

Burst slug detector gear and core restraint tubes are made from stainless steel. In addition, vast quantities of these tubes are being used in chemical plants for the extraction of uranium from the ore and for the removal of plutonium and fission products from irradiated fuel elements.

Accles & Pollock

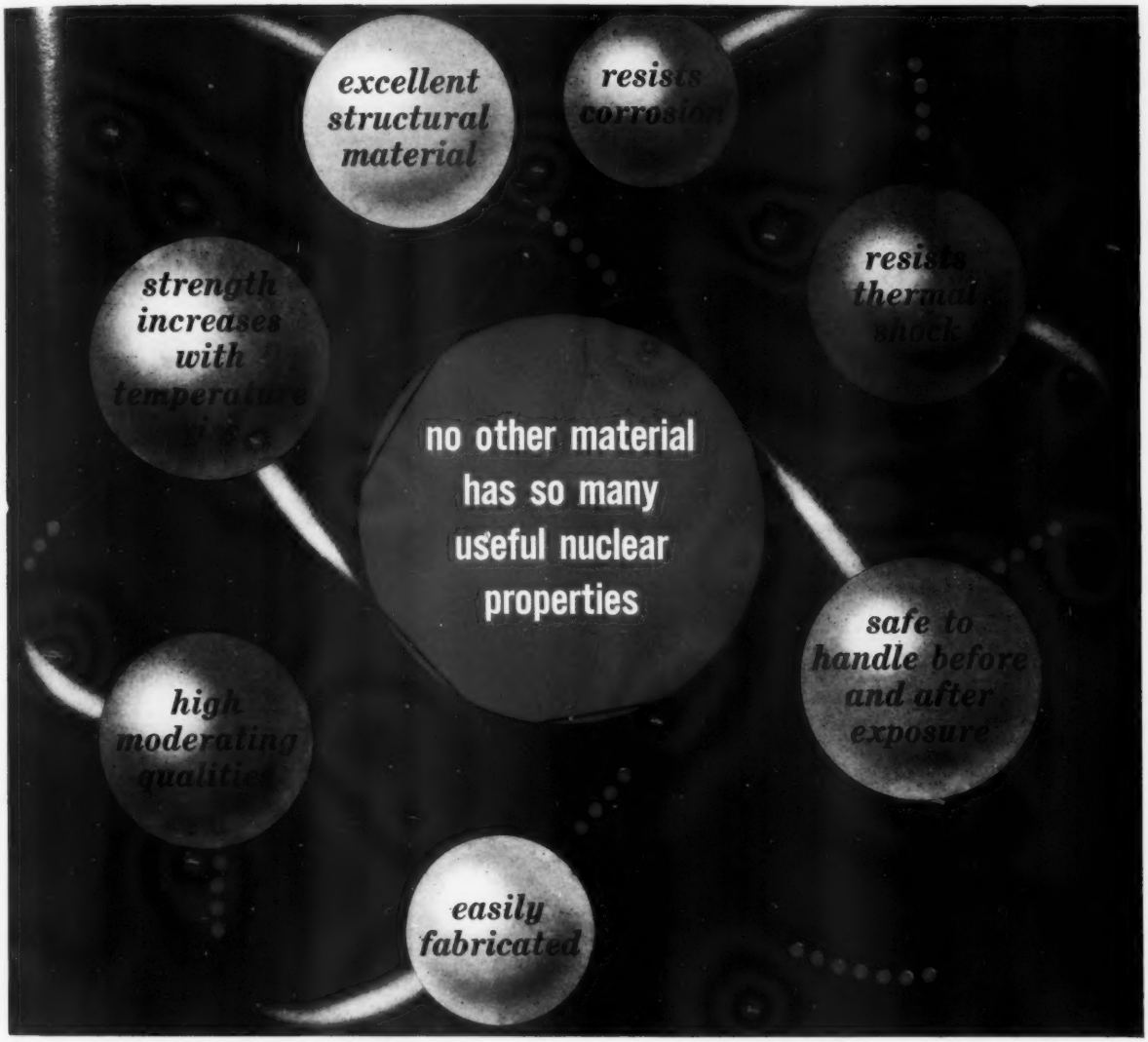
Accles & Pollock Limited · Oldbury · Birmingham · A Tube Investments Company

Makers and manipulators of COLD DRAWN SEAMLESS and WELDED PRECISION TUBES in carbon and alloy steels, including stainless steel and other metals.

"ATOMS FOR PEACE" EXHIBITION, GENEVA

Visit the Accles & Pollock display section on the Tube Investments Ltd. Stand No. 142

TSW.250


excellent structural material
resists corrosion
resists thermal shock
strength increases with temperature
no other material has so many useful nuclear properties
safe to handle before and after exposure
high moderating qualities
easily fabricated

. . . for Moderators, Reflectors, Thermal Columns, Molds and Crucibles

NATIONAL NUCLEAR GRAPHITE

TRADE MARK

from Union Carbide International Company

Division of Union Carbide Corporation

Graphite is the material nuclear scientists call surprisingly versatile. Starting with the very first reactor, science has used this versatility to solve nuclear engineering problems.

NATIONAL Nuclear Graphite was used in early reactors because of its excellent moderating properties and low neutron cross-section. Its low cost, safety, easy machinability and high refractory qualities also combine to make it an indispensable structural material. Moreover, the addition of boron in low percentages makes graphite excellent for shielding.

Whatever your specific requirements . . . extreme purity, unique shapes or sizes, high density, large quantities . . . please write to Union Carbide International Company, 30 East 42nd Street, New York, U.S.A., Cable Address: UNICARBIDE, New York.

UNION CARBIDE

The terms NATIONAL *and* UNION CARBIDE *are trade marks of Union Carbide Corporation.*

20th CENTURY

TUBES FOR REACTOR INSTRUMENTATION

SLOW & FAST NEUTRON DETECTORS

For detecting and measuring thermal neutron flux BF_3 proportional counters are available in which BF_3 gas enriched in B-10 is used at a variety of pressures to cover a wide sensitivity range.
Fast neutron health hazard can be directly assessed by the FN series of proportional counters which are designed to simulate tissue response to fast neutrons.

FISSION CHAMBERS

The fission chamber type B165 operating as a pulse ion chamber, is currently employed as a detector of neutrons in the pulse counting equipment of reactor instrumentation.
Internal coatings of enriched or depleted fissile material are available in the B165 and in smaller chambers which have been designed for use as probes in neutron flux investigations.

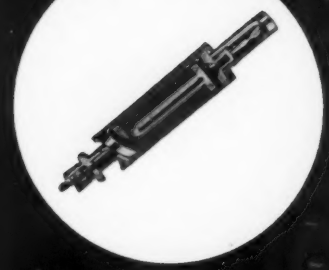
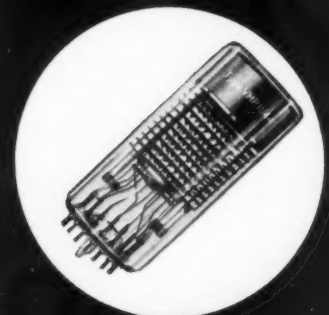


PHOTO MULTIPLIERS

A range of photo-multiplier tubes is available for scintillation counting, energy resolution and applications where linear high current output is necessary.
These tubes employ from 6 to 18 stages of multiplication and the smallest has an overall diameter of $\frac{3}{4}$".



20th CENTURY ELECTRONICS LIMITED

CENTRONICS WORKS • KING HENRY'S DRIVE

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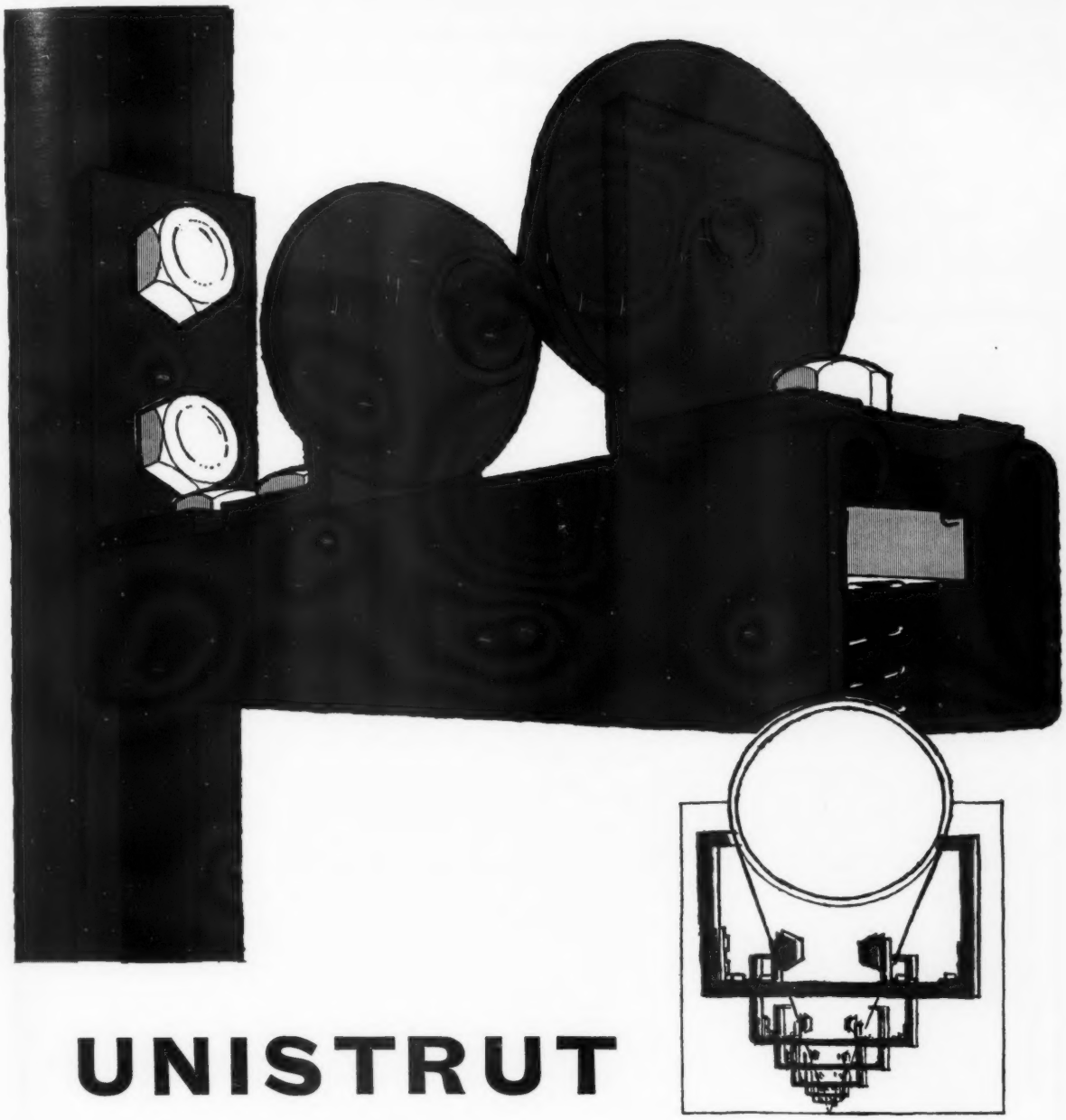


UNISTRUT

STANDARDISED

SPEED AND ECONOMY

IN PURPOSE-MADE

SUPPORT STRUCTURES

Pipe installation is another job simplified by the Unistrut steel channel framing system. The complete load-bearing structure, and individual components such as the adjustable pipe-rollers above, are *rapidly and rigidly* assembled with the Unistrut self-locating nut assembly. Freely (and quickly) adjustable on site, Unistrut facilitates maintenance, since individual components can be withdrawn and replaced at will. Please write for details of the Unistrut system.

FOR PIPING, RACKING AND ELECTRICAL INSTALLATIONS, AND ALL FRAMING APPLICATIONS.

UNISTRUT DIVISION OF SANKEY-SHELDON LTD., DEPT. NP2, 46 CANNON STREET, LONDON, E.C.4

Telephone: CITy 4477. Telegrams: Sankeshel, Cannon-London.

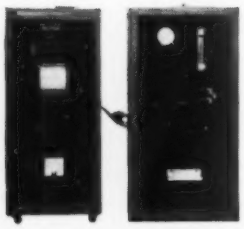
UNI 10284

Solve your process monitoring problems with Tracerlab RADIATION MONITORING EQUIPMENT

SENSITIVE — Tracerlab liquid, air particulate and gas monitors continuously check and record accurately down to — and below — AEC permissible concentrations.*

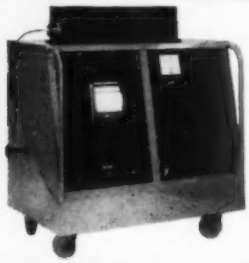
STANDARDIZED — Tracerlab monitors are *standard* units — have interchangeable components — have been in production several years — often eliminate expensive custom-building.

ACCEPTED — In long term use all over the world, in power and research reactors . . . research laboratories . . . universities . . . states and municipalities . . . industrial plants.



FISSION PRODUCTS WATER MONITORS

In production for several years, Tracerlab's Fission Products Water Monitor has maximum sensitivity for fuel element rupture detection in reactors. Resistant to water-chamber contamination and with simple electronics, this monitor provides the highest level of reliability. Available for pressures in excess of 2,000 psi.

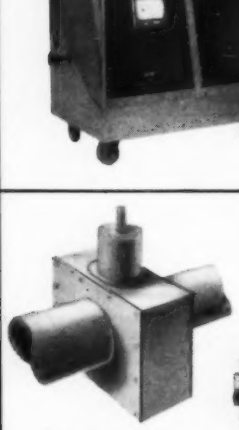


CONTINUOUS MONITORS FOR AIRBORNE PARTICULATE RADIOACTIVITY

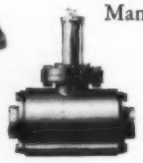
Tracerlab's Beta-Gamma monitors have standard provisions for adding an Alpha detector. Sensitive down to at least 1/10 of permissible concentrations*, they are available with either fixed or continuous moving filters. Immediate Alpha Monitors are also available, built up from standard components. Either can be combined with the Gas Monitor into one system.

RADIOACTIVE GAS MONITORS

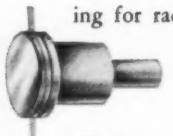
For use in stack gas or ventilation systems for rupture detection or detection of radioactive materials release, these monitors are assembled from standard components, *in production now.* Available with disposable plastic or stainless steel gas chambers. Can be combined with Airborne Particulate Monitors in the same mobile cart, using one pump and one set of controls.



Beta and Gamma



Beta or Gamma



Alpha

LIQUID OR WATER MONITORS

Many effluents and waste and sewage systems require continuous, accurate monitoring for radioactivity. Tracerlab's liquid and water monitors have sensitivities down to or below AEC permissible concentrations for beta, gamma and alpha emitters.

*Permissible concentrations as listed in Part 20, Title 10, Federal Register.

Write or phone us with your radiation and process monitoring problems.

NOTE: Ask about our new equipment for monitoring gaseous radioactive iodine.

Tracerlab inc. REACTOR MONITORING CENTER

2030 WRIGHT AVENUE, RICHMOND, CALIFORNIA · Telephone: LAndscape 5-8510

FIRST IN THE FIELD — AND STILL IN THE LEAD

HEAT EXCHANGERS

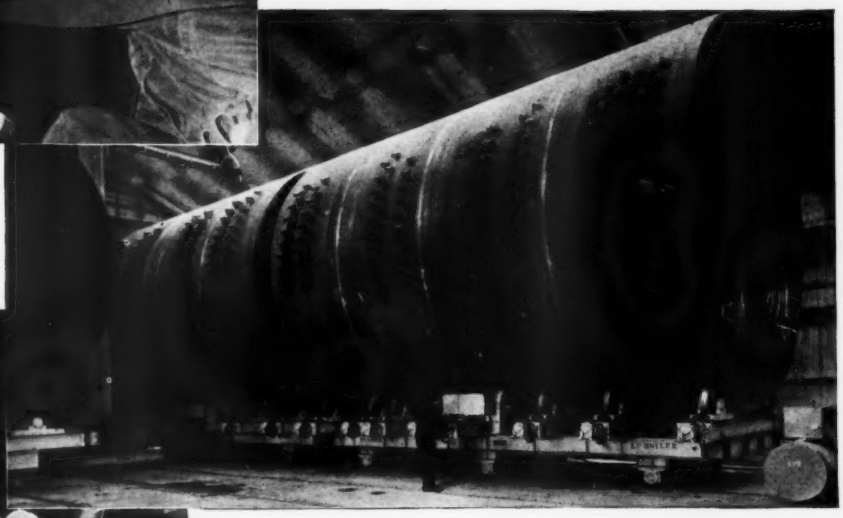
LINCOLNWELDED

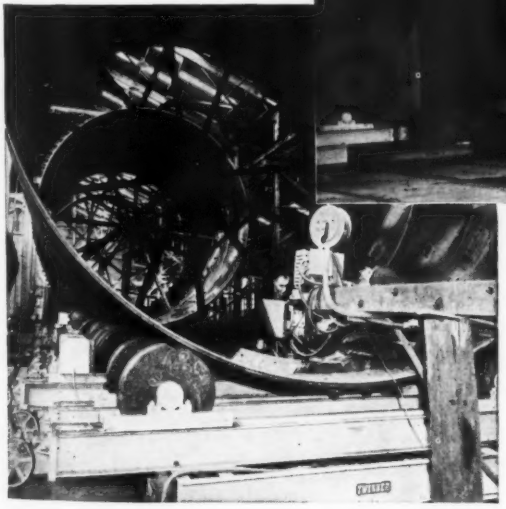
For Bradwell Nuclear Power Station, Essex

The 12 heat exchangers for Bradwell Nuclear Power Station, Essex, each weighing 200 tons, are being designed and fabricated by Head Wrightson & Co. Ltd., a member of the Nuclear Power Plant Company Limited, using 10 LINCOLNWELD Fully Automatic submerged-arc welding units.

The vessels are subject to the requirements of Lloyd's Class 1 Standards for fusion welded pressure vessels, and all the welds are radiographically examined, and finally stress-relieved.

The above photograph shows a close up view of a LINCOLNWELD Fully Automatic submerged-arc welding unit, working on an external weld.





The photographs show (Above) the completed shell of the first exchanger. (Left) an internal weld being made with a LINCOLNWELD Fully Automatic submerged-arc welding unit.

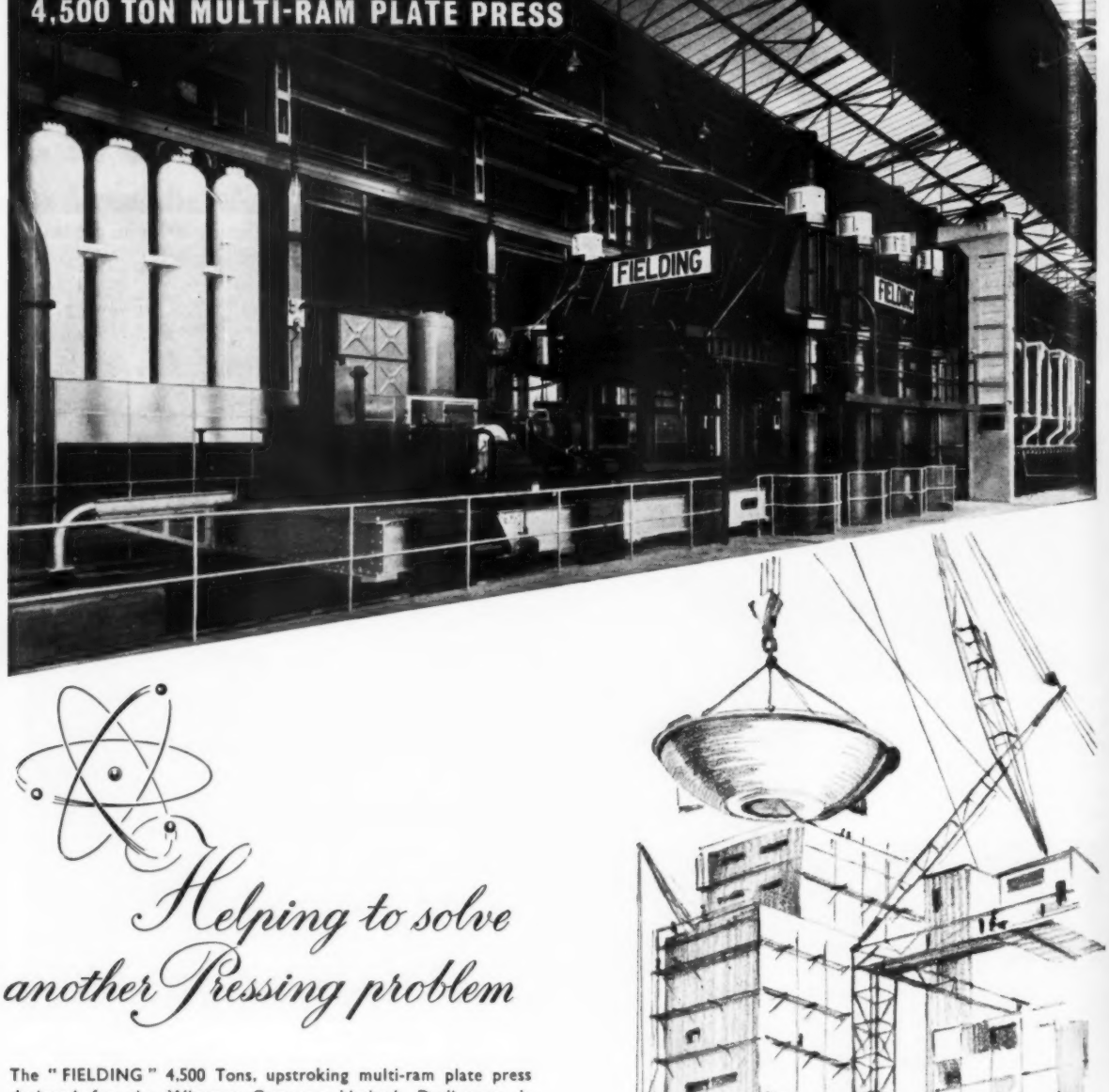
LINCOLN'S wide experience gained from installing hundreds of Automatic Units throughout the world is at your SERVICE.

Write or telephone THE AUTOMATIC DIVISION

LINCOLN ELECTRIC CO LTD

WELWYN GARDEN CITY · HERTS · WELWYN GARDEN 920 (5 lines) 4581 (5 lines)

FIELDING
4,500 TON MULTI-RAM PLATE PRESS



Helping to solve another Pressing problem

The "FIELDING" 4,500 Tons, upstroking multi-ram plate press designed for the Whessoe Company Limited, Darlington, is assisting Britain's race in the field of nuclear power. Shaping the heavy steel plates, required for the shell of giant reactor pressure vessels is only one of the applications to which this press can be applied. It will accept the largest plates manufactured by the British Steel Industry today and still has a substantial margin of power to meet future developments.

This press is only one of the large range of special and standard equipment manufactured by Fielding's; if you have a pressing problem your solution may lie with us. Our Technical Departments are always available to provide information and assistance.

FIELDING PLATT — MEMBER OF THE HEENAN GROUP

FIELDING & PLATT LIMITED · ENGINEERS · GLOUCESTER · ENGLAND

K/FP.23.

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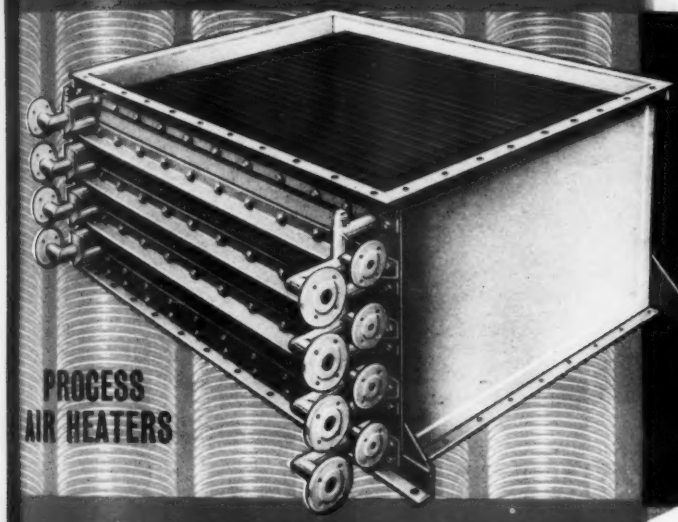
Design
Research
Manufacture

TUBULAR
HEAT EXCHANGERS

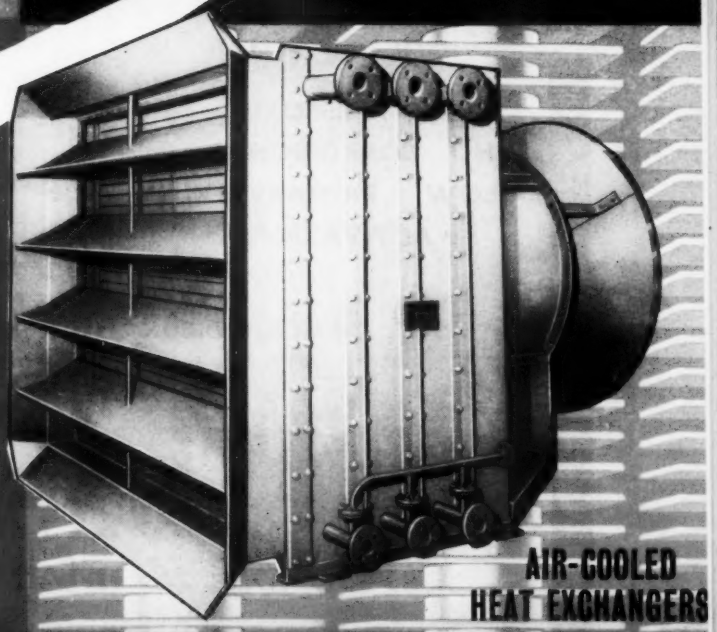


PROCESS
AIR HEATERS

WELDEX
REG'D.

This Division concentrates exclusively on Heat Exchange equipment. May we give your special problem our expert attention?

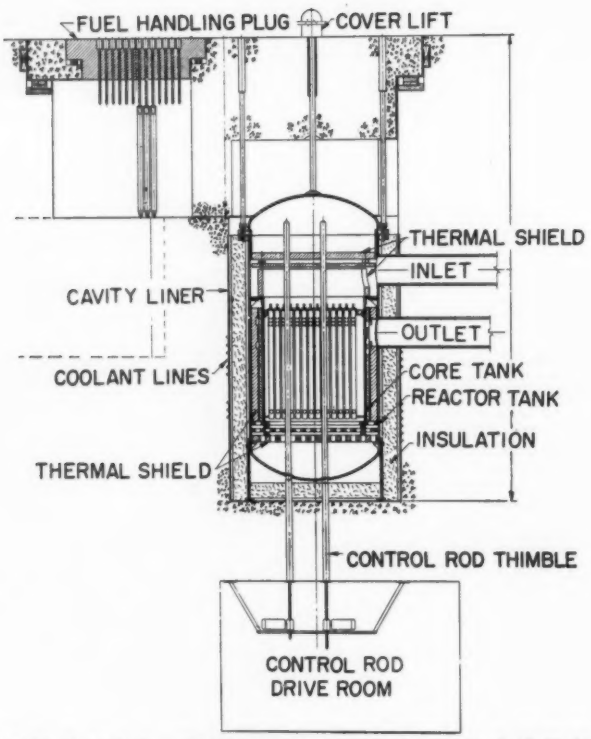
The following literature is available:—
"TUBULAR HEAT EXCHANGERS" Publication 158
"AIR-COOLED HEAT EXCHANGERS" Publication 258
"GILLED AIR HEATERS" Publication 358



AIR-COOLED
HEAT EXCHANGERS

Heat Exchange Division
WELLINGTON
TUBE WORKS LTD

GREAT BRIDGE · TIPTON · STAFFORDSHIRE



ORGANIC MODERATED REACTOR

OMR

KEY TO COMPETITIVE POWER

LOW PRESSURE
NO CORROSION
LOW PRIMARY ACTIVATION

CONVENTIONAL MATERIALS
COMMERCIAL COMPONENTS
MINIMUM INVESTMENT COST
TOP OPERATIONAL SAFETY

DEMAG

INTERATOM

ATOMICS INTERNATIONAL

INTERNATIONALE ATOMREAKTORBAU GMBH.
DUISBURG, FEDERAL REPUBLIC OF GERMANY

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S&L

STEEL TUBES
AND MANIPULATED PIPEWORK
FOR NUCLEAR POWER STATIONS

Heating and manipulating high pressure pipework at Stewarts and Lloyds' Tollcross works.

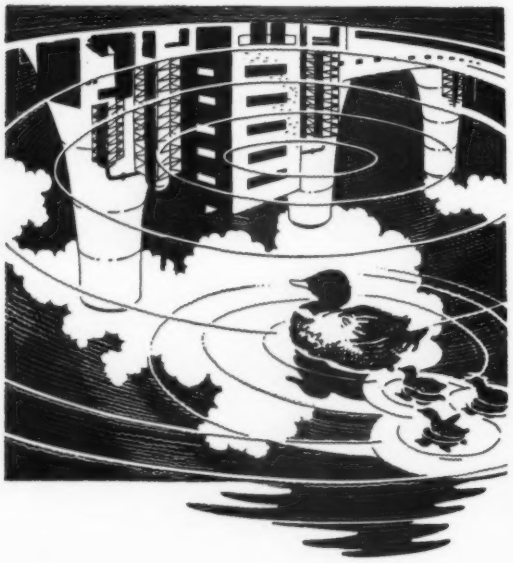
Stewarts and Lloyds have already contributed substantially to the construction of Britain's new nuclear power stations, in which large quantities of steel tubes and manipulated pipework are required.

Contracts in hand include material to be supplied to all nuclear power stations now under construction.

Stewarts and Lloyds design, manufacture and install pipework for all types of industrial plants.

STEWARTS AND LLOYDS
LIMITED

GLASGOW · BIRMINGHAM · LONDON



the source of power changes

...but water is still of great importance

No risks can be taken with the storage of water in modern plants. Tanks must have complete and lasting internal protection.

They should, in fact, be treated with BITOTES Solution and Enamel. Bitotes prevents interior corrosion of water tanks, pipelines, cisterns, reservoirs, and all water containers, cannot crack or peel and is odourless and tasteless when dry. Fully approved for Fresh Water, Drinking Water and Demineralised Water Tanks, etc.

We will be glad to supply you with full details.

BITULAC LIMITED

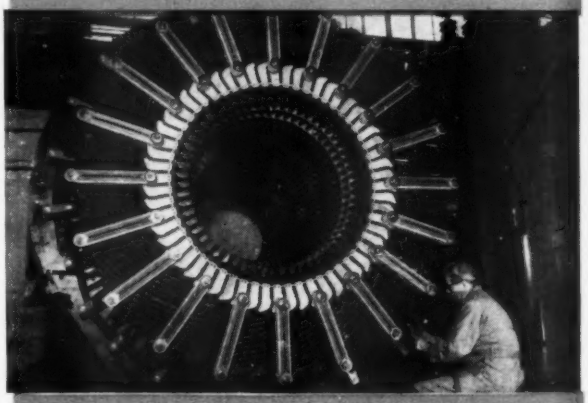
(PAINTS DIVISION)

Collingwood Buildings, Newcastle upon Tyne, 1.
Telephone: Newcastle 2-5401

London Office: 219/220 Dashwood House, Old Broad Street, London, E.C.2.

BEHIND THE SCENES

M & I ELECTRICAL INSULATING MATERIALS



Photographs:— (top) by courtesy of the U.K. Atomic Energy Authority. (lower) by courtesy of C. A. Parsons & Co., Ltd.

"PAXOLIN" and "MICANITE" are in use in the 23 MW air cooled turbo-generators at Chapel Cross Nuclear Power Station—another example of our service to the electrical industry.

m and i the electrical insulation people

THE MICANITE & INSULATORS CO., LTD.,
Blackhorse Lane, Walthamstow, London, E.17
Tel: Larkswood 5600. Grams: "Mytilite", Easphone, London
"PAXOLIN" is a registered trade mark

SPECIAL STEELS FOR NUCLEAR POWER . . .

One of the most essential characteristics implied by the expression 'high quality' is reliability, and the construction of nuclear power plants ranks high amongst those advanced engineering projects, where any doubt concerning the materials of construction cannot be tolerated

Hadfields have contributed in the provision of high quality alloy steels to meet the demand of reactor designers and the "Era" series of Boron Steels was developed to satisfy the special needs of neutron absorption for control purposes. These steels are also used for special shielding applications.

Hadfields have made the Control Rods for Calder Hall and Chapelcross Stations of U.K.A.E.A., incorporating "Era Boron Steels" and "Era H.L.C." special Low Cobalt Stainless Steel. "Era H.L.C." Steel has also been used in the production of a number of other reactor components and is of the 18/8 Stabilised type.

Pressure vessel and heat exchanger forged flanges are made in special "Era C.R." and "Hecla" Steels, and a large number of small castings can be produced in our foundries which are specially equipped for this class of work.

HADFIELDS SHEFFIELD

HADFIELDS LTD., EAST HECLA WORKS, SHEFFIELD, ENGLAND.

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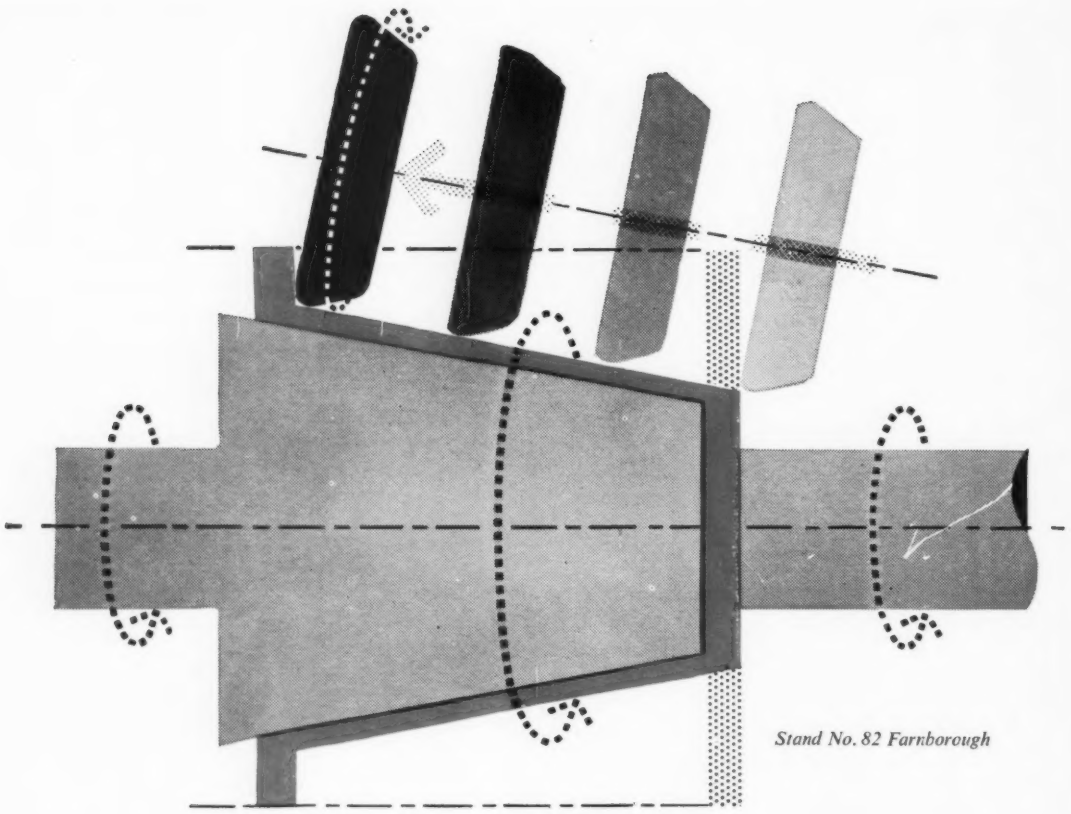


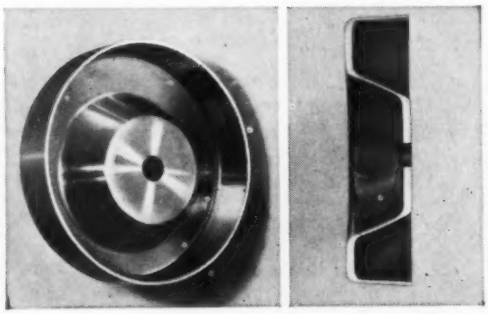
Stand No. 82 Farnborough

A new way with Cones and Venturis

Wilmot Breeden are producing, in the cold state from sheet, conical sections in alloy materials. Flowturning of metal permits conical sections to be formed with wall thicknesses to close tolerances and with thick diaphragms or flanges. The benefits of cold working: increased tensile strength and fatigue resistance, a high surface finish, and substantial economies in time and material.

The illustration above shows the flowturning of a simple conical shape from a circular blank. The diameter and the thickness of the centre and flange remain unchanged as pressure from a roller extrudes the material forming a thin wall section in accordance with the shape of the mandrel.

Complex shapes can be formed. The example on the right shows the Nimonic deflector for the Aden gun in the Folland Gnat fighter. The internal cone is eccentric.



If you have an application for this method of flowturning we should be pleased to investigate and advise.

The illustration is shown by courtesy of Folland Aircraft Limited.

Wilmot Breeden are skilled in metal manipulation

Wilmot Breeden Ltd, Birmingham 1

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Il est souvent difficile au client publicitaire d'indiquer dans un espace restreint tous les détails de ses produits. Dans le cas où vous désireriez de plus amples renseignements à ce sujet, veuillez pointer le numéro approprié sur la carte ci-contre et envoyer cette dernière à NUCLEAR POWER.

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在廣告上以有限的地方來解釋一些專門技術及它們的効果的確是有受限制的困難者請原次善知道一些詳細的情形就請將对頁的表格取一號下來將閣下有疑問的項目用笔勾一下郵寄給子能工程总即可.

讀者サービス

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September 1958

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5	30	55	80	105	130	155	180	205
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22	47	72	97	122	147	172	197	222
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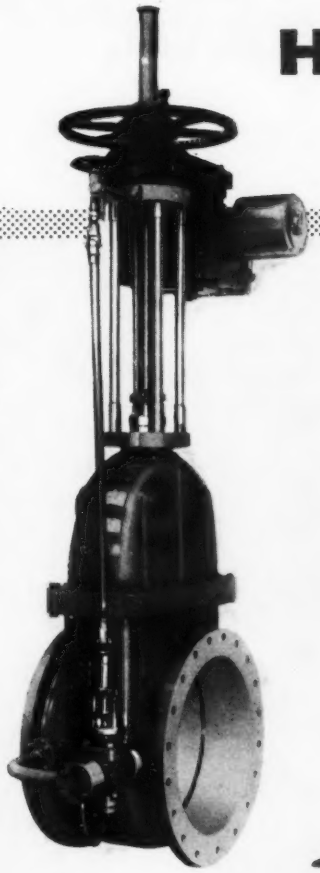

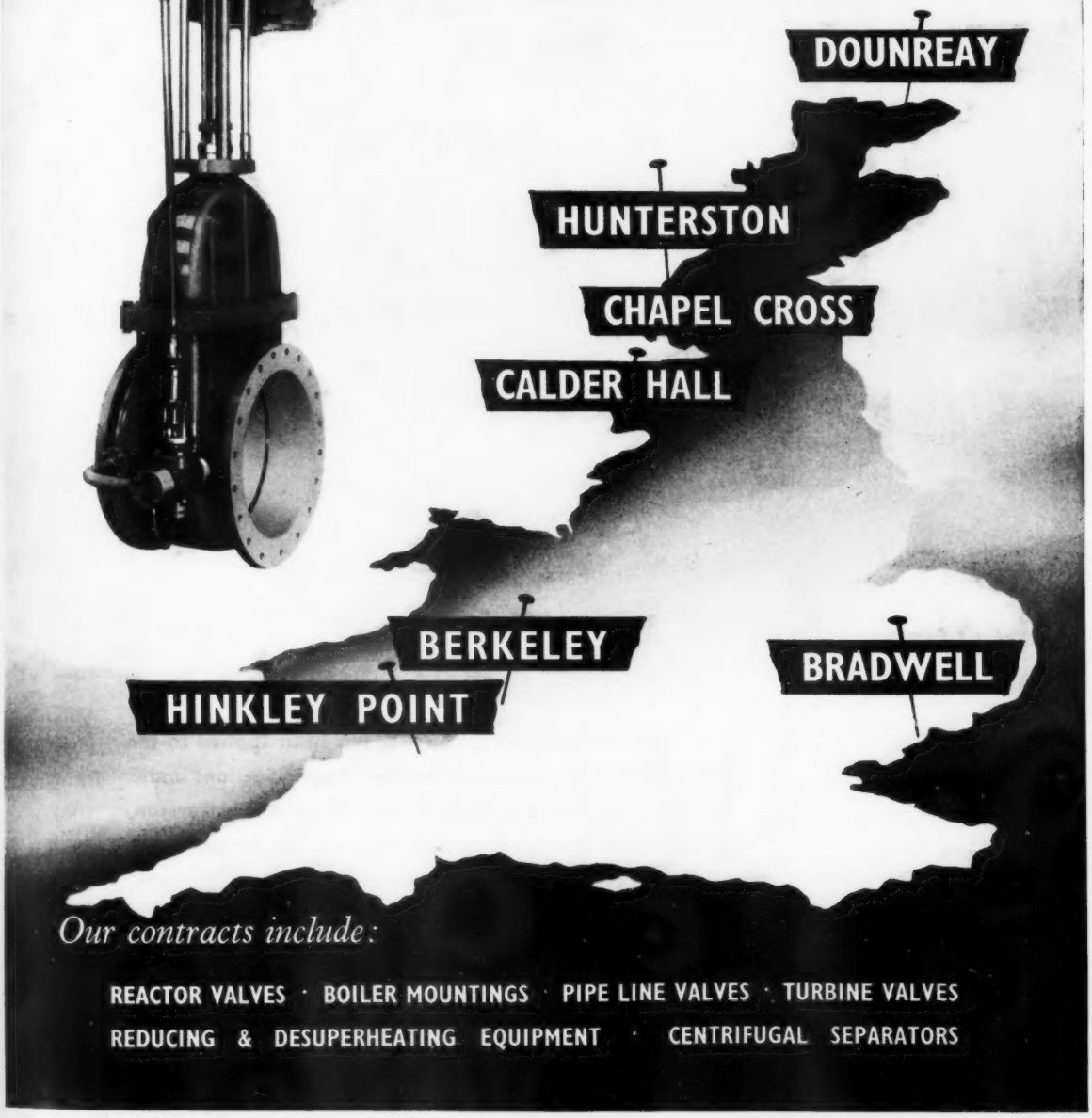

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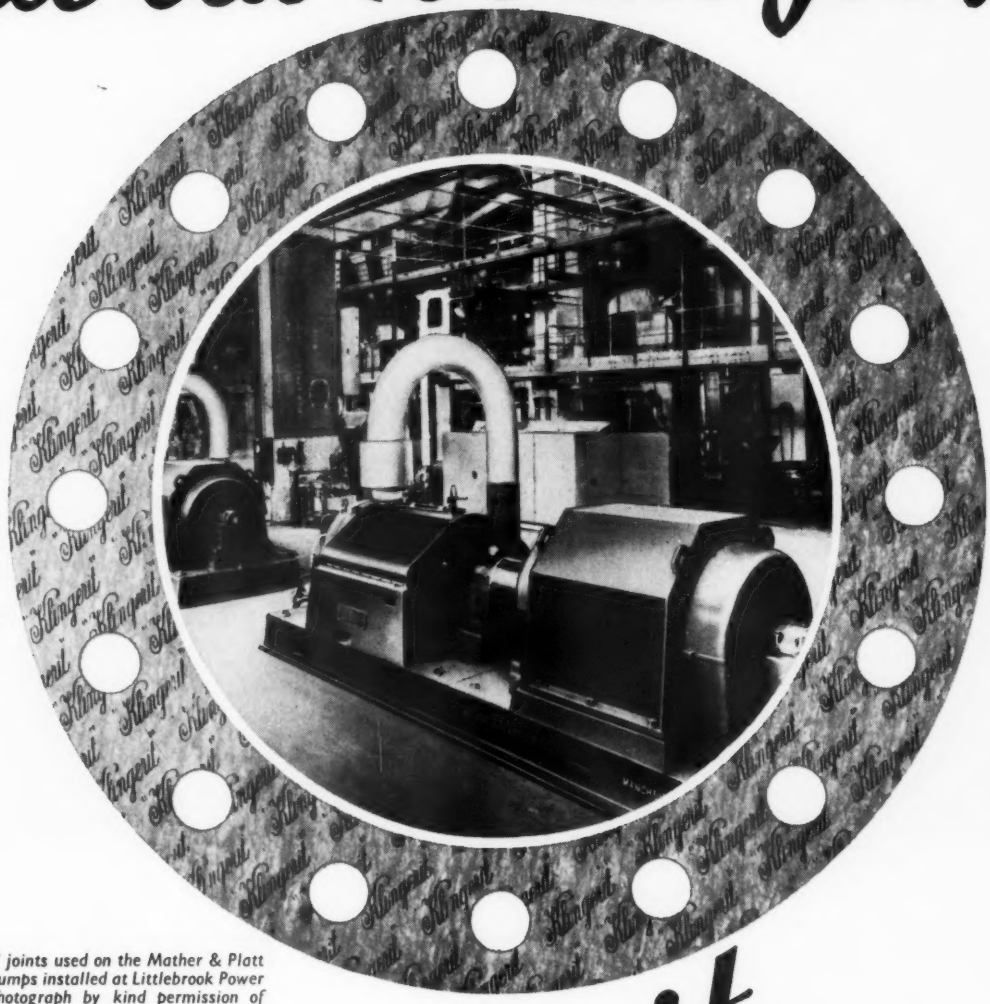

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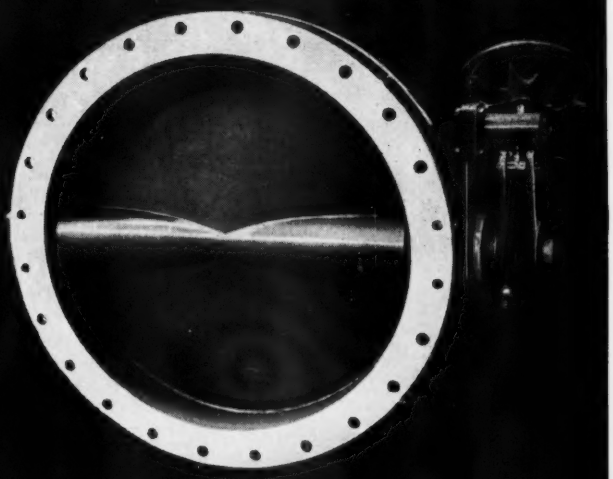

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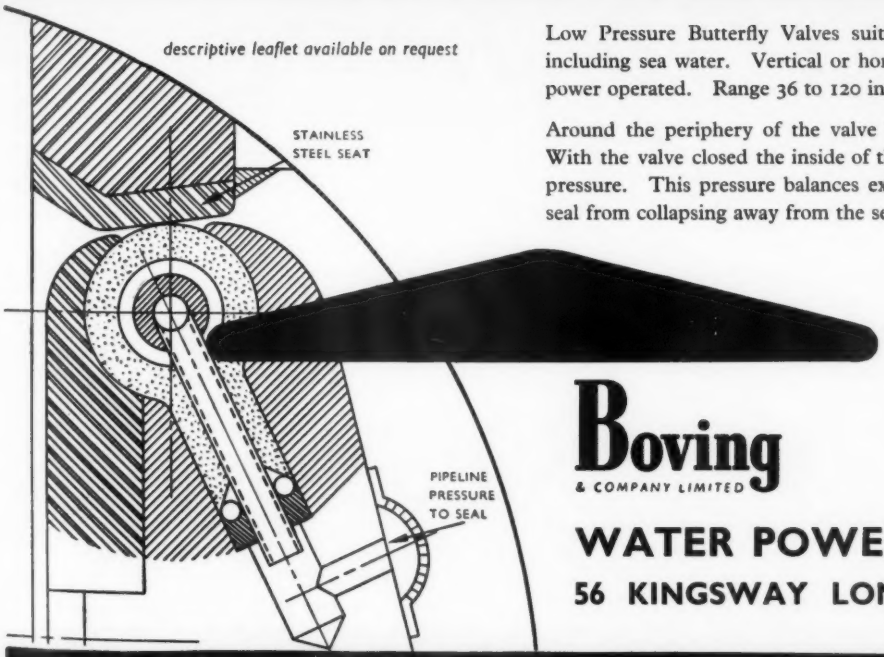

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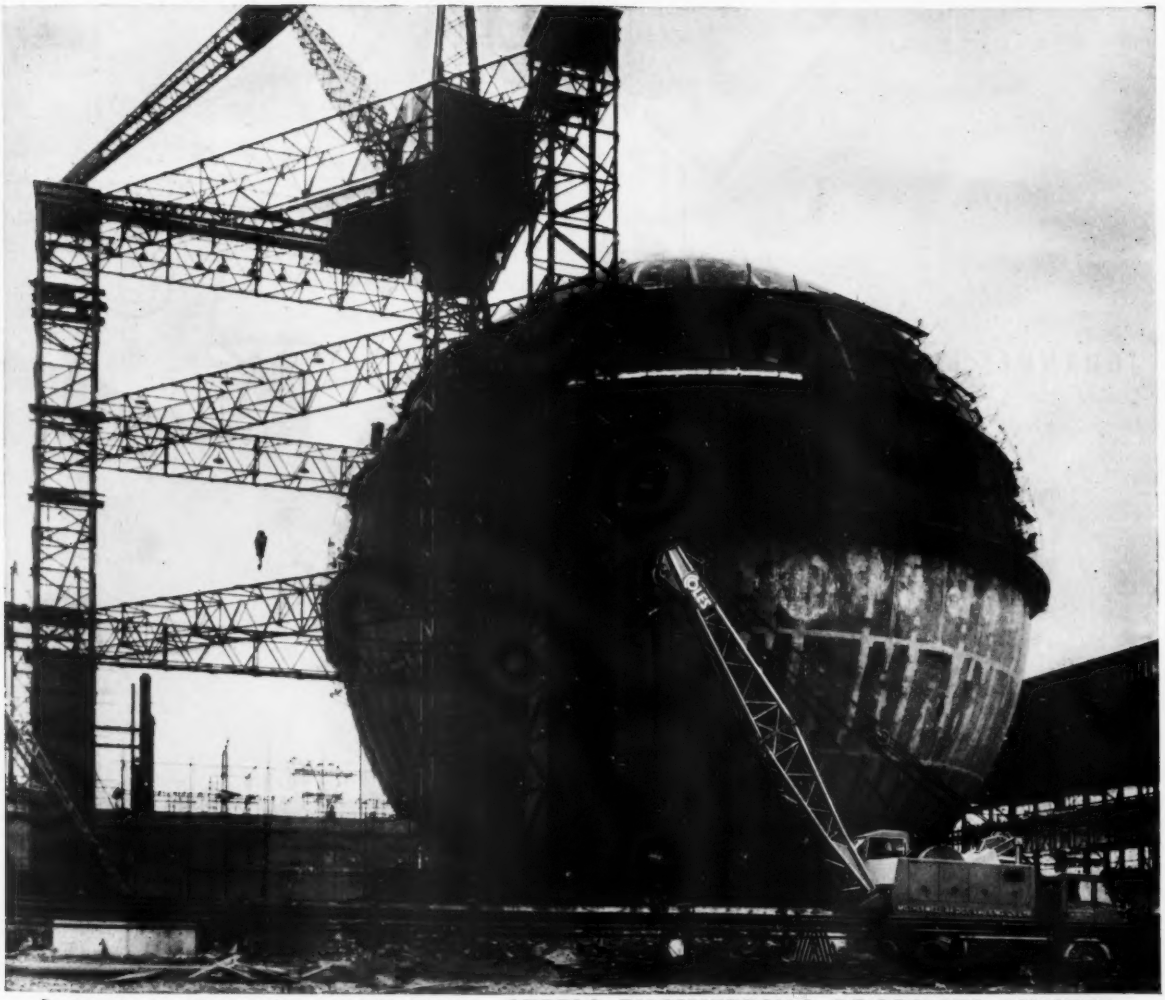

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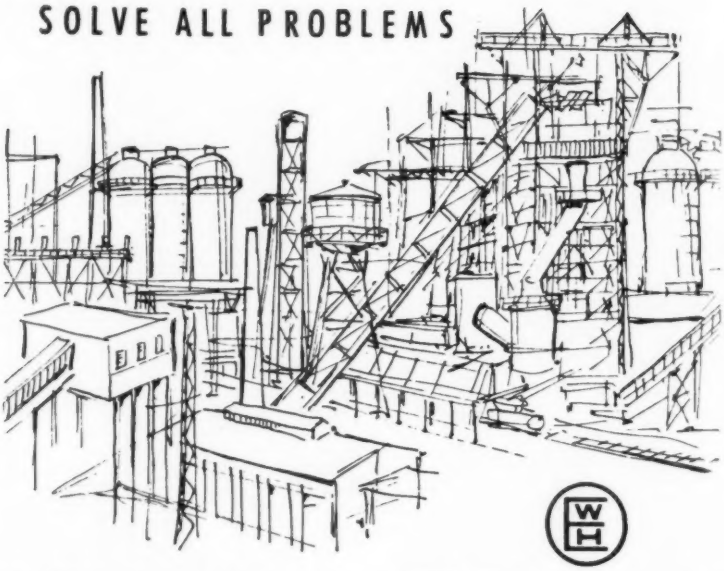

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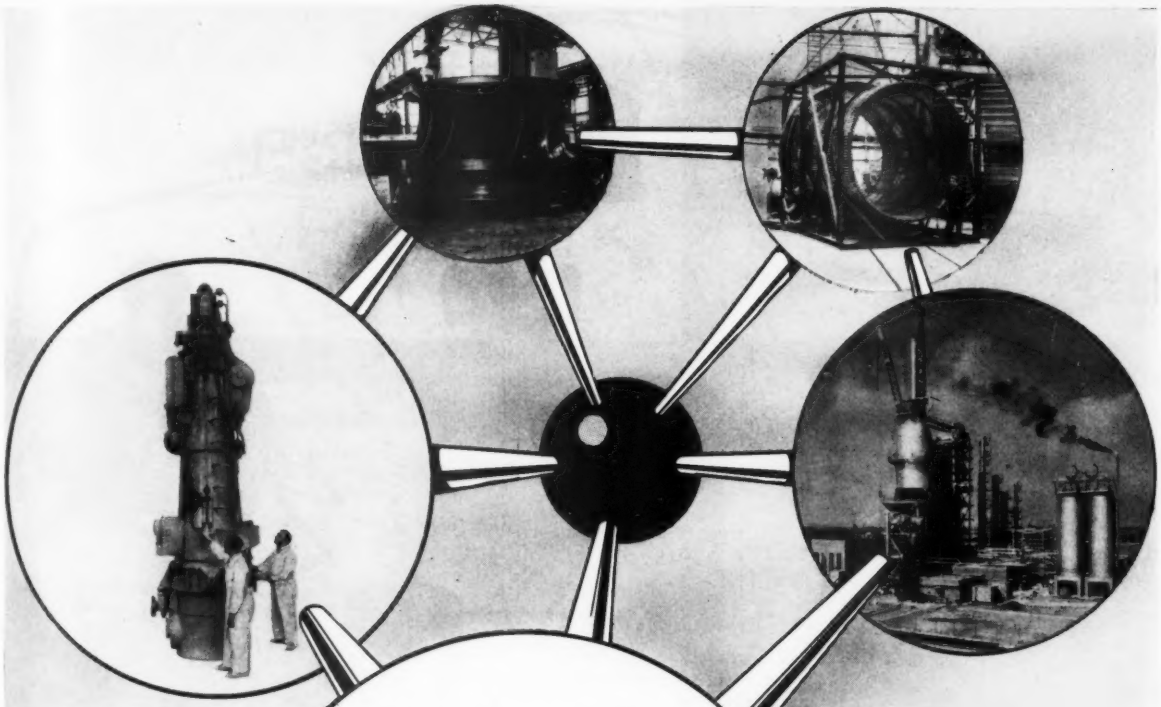

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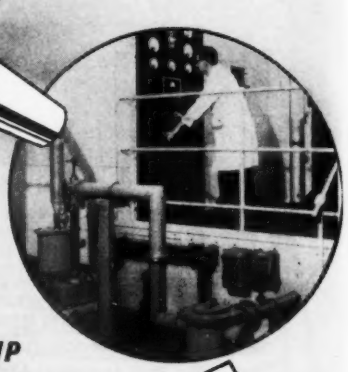

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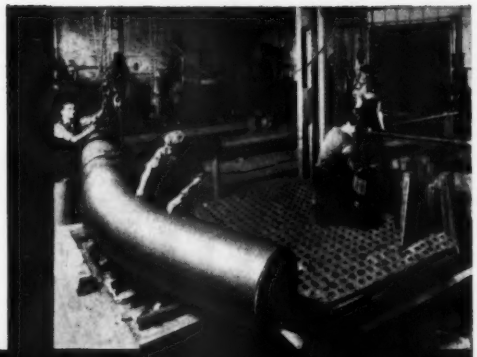

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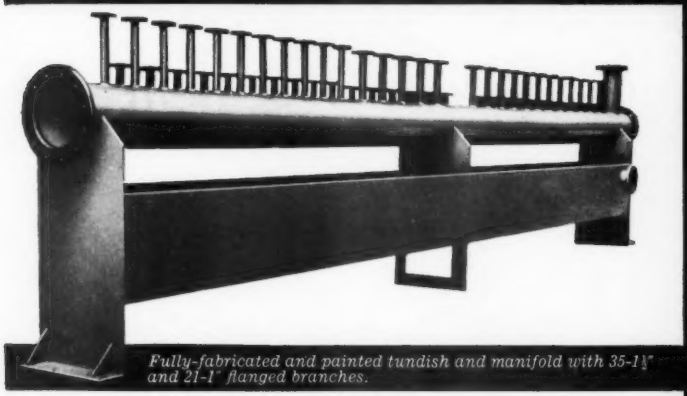
Bonn's Bending Machine installed in one of our bays in full operation.



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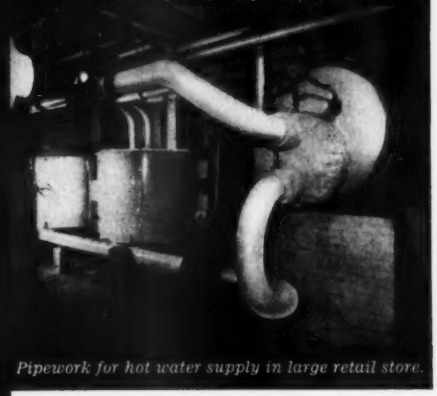

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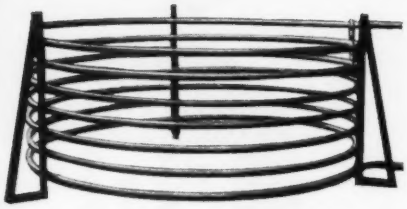

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Publishers Column

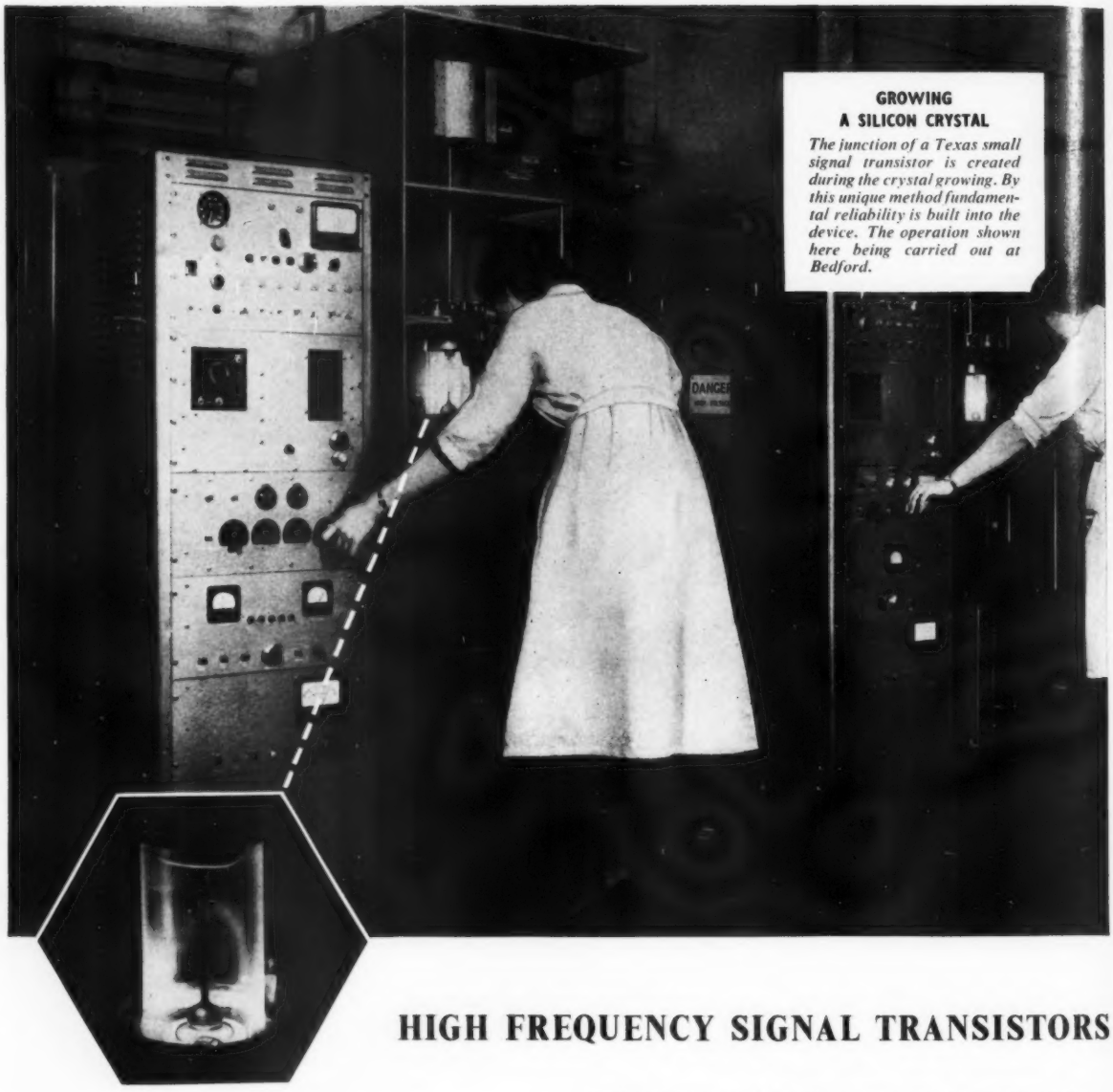
Atoms for Peace

In a few days time nuclear scientists and engineers from all over the world will be starting their trek to Geneva, where the second great United Nations Conference on the Peaceful Uses of Atomic Energy is due to open on September 1.

This magazine traces its origins back to well before the first of these conferences in September 1955. Round about the beginning of that year we became convinced that there would soon be a definite need for an engineering magazine on atomic energy published in this country. But just then the time was not quite ripe because the whole subject was still heavily security-bound although Calder Hall, for example, was already in an advanced state of construction. Came the 1955 Geneva and all that was changed. The curtains, if not completely lifted, were at least parted. Here was the opportunity we had been waiting for. After careful planning, appointment of consultants and staff, we came out in May 1956.

This then is the first Geneva conference NUCLEAR POWER has covered, although editor Bill Davidson was at the 1955 show in another capacity. The task is immense:—a learned conference with over 2500 papers, a huge scientific exhibition containing much material shown in public for the first time, a commercial exhibition forming the biggest purely nuclear show ever staged. We make a start this month with a preview of the *Atoms for Peace* exhibition which we hope will interest both visitors and those not able to get along.

For our coverage of the UN conference in the next issue we have assembled a team of special correspondents all of whom are experts in their own field. Editorially, too, we will be fully represented at the Palais des Nations and this will ensure that all the most important developments are reported quickly and accurately.



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T.13

Hydro power for diffusion

SIR: May I support the suggestion put forward by Mr G. F. Kennedy at the Brighton Electrical Power Convention and reported briefly in your last issue (August p 386) that gaseous diffusion plants be built close to overseas hydroelectric plants.

The advantages of even slight fuel enrichment for the present type of gas-cooled reactor are considerable and for the more advanced types now in course of development it is essential. Now it always seems to be assumed in dismissing diffusion plants as impracticable for civil programmes that they must necessarily be of the enormously complex types used for producing fully enriched uranium. Surely, if only about 2pc enrichment is needed the diffusion plant need only have a few stages?

Taking Mr Kennedy's idea further, one could perhaps visualize some kind of integrated plant comprising hydro plant, diffusion cascade and nuclear power station. At first sight this might appear ridiculous on capital costs but it should be borne in mind that the plant would be a kind of power transformer upgrading the purely mechanical energy in the water into the vastly greater energy in the nucleus. Furthermore, one diffusion plant might well be able to supply several power stations. In a way enriched uranium might be regarded as a key—a very expensive key in the first place, but the key to a profitable business.

London, SE25 A. SATTERLEY

New electrodes

SIR: In your July issue, you were kind enough to mention the new *Ferromax* electrodes which we are now manufacturing. As you stated, the tips of these electrodes now have a special coating (patent applied for) which gives improved performance.

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Is Geneva necessary?

SIR: Now that the Geneva Conference is upon us once again would it be too much to hope that it will be the last? There was ample justification for the first Conference in 1955 and even for this one a case can be made out, but really now that nuclear energy has lost its novelty there is no reason why we should go on like this. I am not against international conferences as such but at Geneva, to any given participant, about 90pc of the papers must seem quite irrelevant. What is needed now is for the various sectional interests to take over the work now done by the UN. For example, the papers on power reactors could well be taken at the World Power Conference Sectional Meetings and the medical aspects would naturally fall into place under the auspices of the various international medical bodies. During the year throughout the world

continued on p A69

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Atomics for peace
GENEVA

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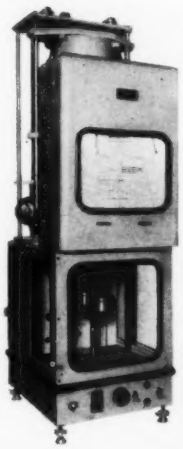

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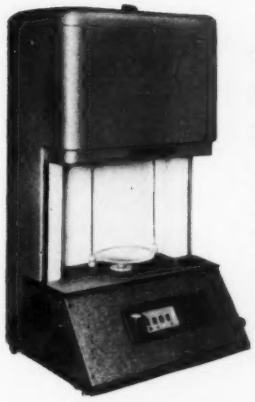

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DESTINATION ARGENTINA: December, 1957 shipment of enriched uranium oxide leaving New York airport for Buenos Aires, Argentina.

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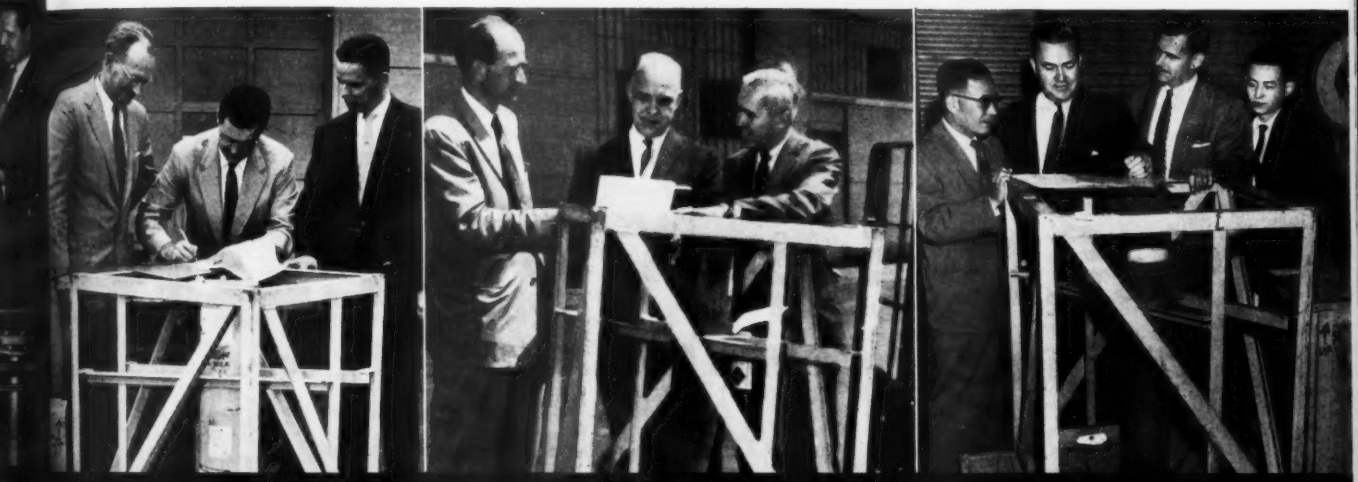

DESTINATION GERMANY: July, 1957, shipment of enriched uranium fuel leaving New York airport for University of Frankfurt.

DESTINATION DENMARK: May, 1957, shipment of enriched uranium fuel material leaving New York airport for Copenhagen.

DESTINATION JAPAN: May, 1957, shipment of enriched uranyl sulfate leaving San Francisco airport for Japan.

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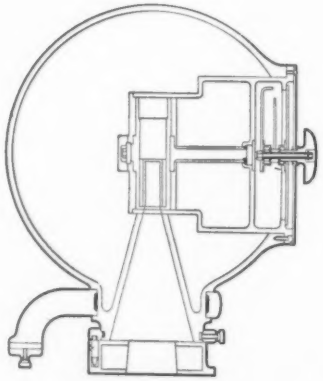

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SIR!

continued from p A65

there are international conferences on every conceivable subject and atomic energy is now beginning to impinge on most of these. It would be a good idea if atomic energy were now put into its proper place as a normal activity instead of something very special cutting across all others.

Oxford J. K. ROSENBERG

Navigating Nautilus

SIR: The account of Commander Anderson's voyage under the North Pole in the atomic submarine *Nautilus* has fired the imagination of all. There has been a lot of speculation as to how the ship was able to navigate in the Polar regions because it is well known that magnetic compasses and also gyros behave erratically in this vicinity. I have not seen it suggested anywhere but is it possible that *Nautilus* may in fact have been guided under the ice. This I think could perhaps have been achieved by placing marker beacons on the surface of the ice by low-flying aircraft, which can locate themselves accurately by astro-navigation. The beacons might be radio or perhaps more likely ultrasonic transmitters and all the submarine would have to do would be to steer from one to the other. I have no special knowledge of these things but I wonder if it is possible. If it is, it might be the best way of marking out regular submarine routes under the polar ice.

These remarks by the way are not intended in any way to reduce the widespread admiration for this courageous voyage.

Gloucester M. J. FULLER

▶ *We have no special knowledge either on navigational problems but there might be something in the idea.* Nautilus *however did not use beacons—according to her captain she had an 'advanced inertial type guidance system.'* *Ed.*

Scientists' dilemma

SIR: Your reviewer of Jungk's *Brighter than a Thousand Suns* (NP July) seems to have a limited view of history if he believes that the dilemma which faced the atomic bomb pioneers in 1945 was a particularly novel one. War has always—at least since medieval times—been considered a science and those who waged it have always relied on the scientist and engineer to invent for them a weapon superior to those used by their enemies. Furthermore, with very few exceptions there has been no lack of support from the scientists. It would be monotonous to catalogue those eminent men who at some point in their careers have contributed to warlike operations and it seems to me that, in principle, the atomic bomb was no different from, say, poison gas, machine guns, gunpowder or even the cross-bow.

Trenton, NJ A. NAUMANN

▶ *Our reviewer writes:—The atomic scientists' real problem was that for the first time in history their invention seemed to be capable of mass destruction of civil populations as opposed to combatants. As it happened Hitler managed this with conventional weapons but the scientists did not know this at the time.* *Ed.*

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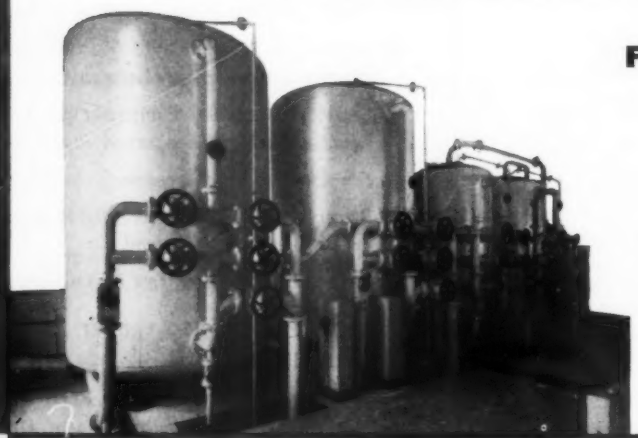

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Nuclear Power
THE JOURNAL OF BRITISH NUCLEAR ENGINEERING
SEPTEMBER 1958 VOLUME 3 NUMBER 29

Geneva Prospects

When the 5000-odd participants assemble in the United Nations' Palais at Geneva on Monday, September 1, to attend the Second Conference on the Peaceful Uses of Atomic Energy under the presidency of Francis Perrin, High Commissioner of the French *Commissariat à l'Energie Atomique*, they will face a fortnight of furious activity. With about 500 papers to be discussed (2000 more will be merely 'tabled'), two exhibitions and innumerable private conferences and receptions, it will be small wonder if they return to their work slightly dazed. For some indeed, the circus will not be over then. A certain number will be going on to the Second Session of the General Conference of the International Atomic Energy Agency in Vienna. Others will be travelling to the nucleonic instrument conference in Paris and Commonwealth delegates will be coming to England for the talks at Harwell and elsewhere. Some indeed might also be attending the Montreal Sectional Meeting of the World Power Conference which overlaps Geneva and a few might be coming from the British Association meeting in Glasgow. Thus in the world of atomic energy the late summer of 1958 will go down as a period of unprecedented international activity.

The second Geneva Conference can hardly have the dramatic appeal of the first *Atoms for Peace* but it is certain that it will have more solid achievement to report. Several power plants that had then only just started construction are now in operation and many others which were just projects are now well under way. It should not be forgotten however that even now there are only about six nuclear power stations actually working—Calder Hall, Shippingport, EBWR, G1 and G2 and the original Russian 5MW plant—so that broad technical and economic experience is still somewhat lacking. The Russians are down to read a paper on the *Lenin* ice-breaker and it would be no surprise if it were disclosed to be now operational. It might also be that they have one or more full-size power stations now working.

The papers on thermonuclear fusion are certain to command great attention in view of the disappointments contained in recent statements. Whether or not there has been any real break-through yet on either the Soviet or Western side will probably remain in doubt until the Conference, but it is certain that both teams in the scientific race are straining every nerve to come up with some kind of answer.

These then are the glamour subjects but atomic energy is much more than this. On the Life Sciences side, for example, the new techniques now available have made and are making a perceptible inroad on the problems of conquering disease and want. The metallurgists, physicists and chemists are not only bringing economic power within reach of all but are also steadily pushing back the frontiers of knowledge with an inestimable effect on science and technology generally.

Apart from the papers, one of the great attractions of these conferences is, as Sir John Cockcroft says elsewhere in this issue, that they provide a unique opportunity for scientists from all over the world to get together informally over their pet subjects. For them, and for all attending, the 2nd Geneva Conference should be a rewarding and inspiring experience.

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Worldview

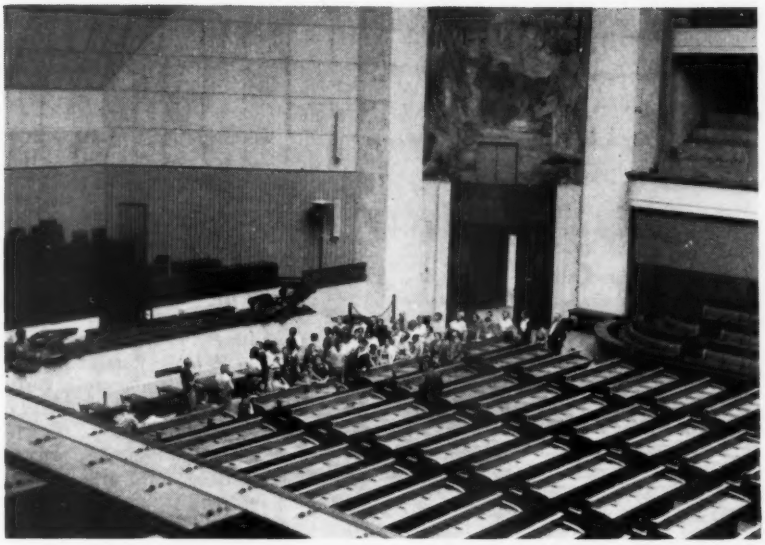
the month in atomic energy

ALL SET FOR GENEVA

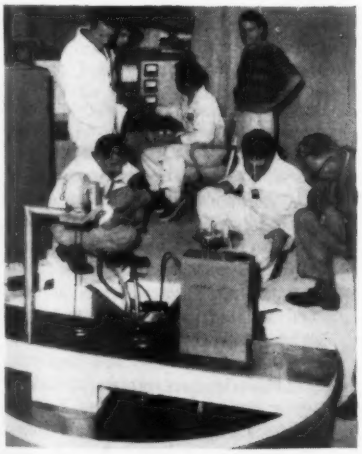
But Soviet plans still vague

Preparations in Geneva for the 2nd UN conference are now well advanced and many exhibits for the scientific exhibition in the specially-constructed building in the grounds of the Palais des Nations are already in place. It has now been announced that the British delegation will be led by Sir John Cockcroft, the other four delegates being: Sir Leonard Owen, Managing Director of the AEA Industrial Group; Sir Willis Jackson, representing British industry; Sir George Thomson, nominated by the Royal Society and Dr J. F. Loutit, Medical Research Council. British advisers, including authors of papers will number about 250 and there will be around 300 observers—drawn from the Authority and industry. Over 200 British papers were submitted and of these 87 are to be read.

The 9000 sq ft temporary exhibition hall is complete and will contain exhibits from 20 countries, by far the largest of which is the United States with 36,000 sq. ft. With a reported expenditure on the exhibition of $M4, the American section will cover four main aspects of atomic energy—Basic Sciences, Life Sciences, Fission Reactors and Fusion Reactors. The Fission Reactor section will be unique in having the only working reactors at the exhibition—a 30 kW General Atomics TRIGA which will be producing short-lived isotopes for other parts of the US exhibit—and a 10 kW Argonne ARGONAUT training reactor which will be assembled and put into operation during the conference. Very spectacular should be a full-scale model of the Shippingport PWR core and pressure vessel.



Sightseers look round the Palais des Nations' Assembly Hall. Scene of the former League of Nations debates, it will soon be filled with delegates for the general sessions on the peaceful uses of atomic energy



TRIGA This 10-30 kW reactor, installed as part of the US technical exhibit, is already in operation

US fusion exhibits will range far and wide and will include working apparatus from Princeton, Berkeley, Oak Ridge and Los Alamos.

New British fusion device

Thermonuclear devices will also be a feature of the British section and in addition to models of ZETA and SCEPTRE a working model of the Aldermaston cylindrical shock-wave machine will be shown. British reactor models will include the high-temperature gas-cooled reactor experiment now building at Winfrith Heath.

France should have a particularly good showing and included in the French section will be a demonstration of the on-load fuel-charging used on G2 and G3.

The National Centre for Nuclear Research at Ispra will be featured on the Italian section of the exhibition. Here will be seen a model of the Ispra CP5 reactor which is due operational before the end of the year.

One of the best exhibits at the last Geneva conference was that of Canada and this year Atomic Energy of Canada look like having another good show. Naturally the emphasis will be on uranium mining and production but there will also be models of the redesigned NPD reactor, the Westinghouse horizontal pressure tube reactor and a preliminary design for CANDU (Canadian Deuterium Uranium)—a large-scale development of NPD.

So far there is no news whatsoever of what the Soviet Union intends to show but she has booked twice the space that Britain has.

The Conference Secretary-General Sigvard Eklund recently announced names of the speakers at the six evening lectures. They are: Friday Sept 5, Homi Bhabha (India). *Nuclear power in undeveloped countries;* and Igor Tamm (USSR), *Recent developments in fundamental physics;* Wednesday Sept 10, Glenn Seaborg (US), *Transplutonic elements* and Vladimir Engelhardt (USSR), *Atomic energy and biology;* Friday Sept 12, Lloyd Berkner (US), *International Scientific collaboration* and Sir John Cockcroft (UK), *Development of peaceful uses of atomic energy.*

The UN have announced that visitors may attend the exhibition and evening lectures by applying to the Secretariat, UN International Conference, Palais des Nations, Geneva.

Welsh station gets go-ahead

The CEGB's fifth nuclear power station is to be built at Trawsfynydd in the area of Snowdonia National Park in spite of some objections raised at the public inquiry in February (*Worldview* March). Announcing the decision, the Ministry of Power says that owing to the lie of the land it will not be possible to see the £M50 station from the greater part of the National Park. 275 kV supergrid lines will connect it with the pumped storage scheme at Tan-y-grisiau and the grid at Connah's Quay. Suggested sites in counties such as Anglesey and Cardigan, states the Ministry, would involve very much longer transmission lines. No other site in the region, and no site on the coast east of the Menai Straits would satisfy the necessary conditions of good foundations, comparative isolation and abundance of cooling water. The second site considered suitable by the CEGB—at Edern—may be used for a larger station.

Weapons man to watch CEGB safety

A department for nuclear health and safety is to be established by the Central Electricity Generating Board. First head will be C. A. Adams, who will move from his present job as chief of

C. A. ADAMS

In at the first tests

trials and safety at the Atomic Weapons Research Establishment, Aldermaston.

Since leaving London University Adams has worked in several Government research establishments, mainly in connexion with the development of nuclear weapons. He was in at the beginning as deputy technical director for the first British bomb tests under Sir William Penney and acted as scientific superintendent in the 1953 trials. For the Monte Bello tests he took over the job of scientific director. After the 'megaton' trial at Christmas Island in 1957, where he worked under Sir William Cook, he ran his own series of tests as director. No date has been fixed for the beginning of the new CEGB department and the AEA has not yet decided who is to replace him at Aldermaston.

Fast reactor pact with US

Knowhow on the development of fast breeder reactors is to be exchanged officially in future between the Atomic Energy Authority and the Power Reactor Development Company of Detroit, US. The agreement, which comes into force on October 1 for a period of five years, follows the unofficial exchange of information on the Dounreay Fast Reactor and the Enrico Fermi Atomic Power Plant that has been going on for some time.

All four of the world's power projects—the others being EBR-II at Argonne and a 50 MWe Russian reactor—will use liquid sodium cooling. First to come into operation will be the 15 MW DFR, which in spite of recent delays is expected to go critical at least a year before the other three. Original date was spring 1958, but the British lead has been whittled down by technical difficulties and staff problems (*Worldview* July). The Enrico Fermi plant (see *Industrial Newsdesk*) is scheduled for 1960 and with an ultimate planned output of 150 MWe is by far the largest. The Russian reactor was last reported due to start early in 1960, and EBR-II will begin delivering its 20 MWe a little before this. It is a USAEC project and information can be exchanged with the AEA at official levels without the need for an agreement of the type just made.

Commonwealth scientists to meet

Over thirty scientists from nine countries will come on from Geneva to attend the Commonwealth Conference of nuclear scientists which will be held from September 15 to 20. Organized by the Commonwealth Relations Office and the Atomic Energy Authority, the main idea of the Conference is to show delegates the work being done at the various UK nuclear energy establishments. The opening session at Harwell will be given over to a discussion of Commonwealth requirements and recent developments relevant to its needs; after two days there the party will fly in a chartered *Viscount* for visits to Calder, Dounreay, and one of the Central Electricity Generating Board nuclear power plants—probably Bradwell.

The need for a formal Commonwealth organization on the lines of Euratom was urged in the Commons recently but the Prime Minister's response was luke-

continued on p 398

A YEAR OF CONCENTRATION

Fewer projects—more staff revealed in AEA Report

A growing tendency to concentrate on two things—advanced gas-cooled reactors and thermonuclear fusion—is apparent from the 4th Annual Report of the United Kingdom Atomic Energy Authority, published at the end of July (HMSO Price 4s 6d). Covering the period April 1, 1957 to March 31, 1958 it reports 'substantial progress' in the fields of defence, civil applications, consultancy service to the electricity authorities and collaboration with industry. Here are some of the highlights amplified by later information given at a press conference presided over by Sir Edwin Plowden.

POWER REACTOR POLICY

Long-term Things are moving so fast that no firm policy should be laid down.

The 1960's Primary object is to push gas-cooling to the limit with first AGR, then HTGR.

Heavy water Gas-cooled system looks good and might be commercial by late 60's. Main problems now under study: header design, moderator cooling and heat transfer.

SGR Sodium-graphite reactors are thought too complicated and unlikely to be economic. Work abandoned.

Homogeneous Both aqueous and liquid-metal-fuelled systems show 'little prospect'.

Fast Breeders They 'may' have reached commercial status by 70's.

Fusion Thermonuclear—good progress but still impossible to say when it will be a proposition.

POWER REACTOR EXPERIMENTS

AGR Advanced gas-cooled reactor to be built at Windscale. Planning started Sep 57. Intended to use beryllium-clad uranium oxide elements enriched to about 2C_o. It should have a mean core rating of 8MWt/tonne of uranium contained, with parts reaching 18MW. Work expected to begin soon for commissioning mid 61.

HTGR High temperature gas-cooled reactor experiment now being built at Winfrith Heath should be operational mid 59. Zero-energy, the nitrogen coolant will be raised to 800-900°C by electric heating. Several variants of the idea are proposed since graphite or beryllium could be used as moderator and there is a choice of gas. Also, fission products could be retained in impermeable element or allowed into the

cooling circuit and continuously removed.

SHIP PROPULSION

PWR Pressurized water reactor considered ideal for submarines and possibly for merchant ships too if cheap enriched fuel were available. Work continued with NEPTUNE zero-energy assembly but likely now British sub will have Nautilus-type plant.

AGR Merchant ship propulsion not on very high priority but it's been decided a scaled-down Calder reactor would be no good—it would have to be an AGR. Design study will go on for year—if it works ship should be commissioned 64-65. Gas-cooled heavy water system has been studied but no decision has been made.

OMR Organic moderated reactor has also been studied and a PLUTO loop made. Believed amount of development work would not be large.

EXPORT REACTORS

Size Believed main demand is the 30MWe class and proposed ship systems could meet this. But 'considerable' development work is necessary.

THERMONUCLEAR

ZETA Now being modified—different linings etc.—to ZETA IA. Next step is to boost current and this will make it ZETA IB which will be operating next year. ZETA II—a much bigger toroidal machine—is on the drawing-board.

Another Approach Revealed Weapons Establishment working on straight tube with cylindrical shock wave heating. Current rises of 5 billion amps per sec. have been reached. Neutrons were obtained but their origin in doubt.

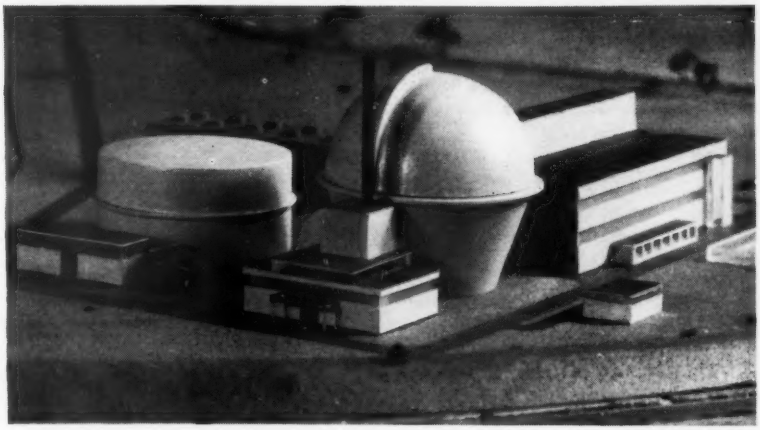
DOUNREAY

Delay Windscale accident—and modifications inside the vault—have caused delay to Fast Reactor. A relatively low priority project. It will be handed over for commissioning this autumn but is not expected critical till next summer. Even then it will have a long period of low power operation before it is stepped up to design output. Manufacture of fuel elements started in July 57 but in August those made were scrapped for a design modification.

DMTR Materials Testing Reactor went critical in May.

REACTOR OPERATIONS

Calder output In Aug 57 no 1 reactor at Calder A was flux flattened and the output stepped up from 184 to 200 MWt (45 MWe). During year only one burst slug was found. In no 2 reactor four bursts were found. During period April 1, 57, to March 31, 58, Calder A exported 438,797,000 units. At Calder B—no 1 went critical in March.



THE NEXT STEP FORWARD Model shows the main lines of the Advanced Gas-cooled reactor, building of which is expected to start in the autumn at Windscale. It will use UO_2 and push gas temperature up to about 600°C

AT HARWELL AND ALDERMASTON

New reactors PLUTO went critical Oct 57, DIDO has operated at rated flux for 80 pc of its time. NEPTUNE went critical in November and HAZEL (formerly ZETR II)—an aqueous homogeneous assembly—first started in Feb 58. ZEUS—the Dounreay zero-energy uranium system—was dismantled.

New Name The AEI MERLIN reactor under construction for the Weapons Establishment at Aldermaston is called HERALD.

RAW MATERIALS

Uranium Since the 3rd Report it has been found that 'for some years at least, more uranium may be available than will readily be bought.' No more long-term commitments will be made at present but the Authority will continue to encourage prospecting. 7000 sq miles in S. Rhodesia were air surveyed.

Beryllium A contract was placed with a French company for a modest tonnage of beryllium metal for the AGR. Beryl purchases were increased and concentration methods developed.

Helium Drilling for helium started in Tanganyika.

Thorium No further commitments for thorium concentrates were made.

PROCESSING PLANTS

Springfields Magnesium reduction process has been improved and the uranium casting operation has been simplified. Commissioning of the new extraction and metal reduction plant is expected soon.

Capenhurst Diffusion plant has operated continuously and extensions and improvements are reported. The first stage in reconversion of hexafluoride to metal is now done at Capenhurst. New techniques reported for enrichment determination but no details.

Windscale Modifications to the plutonium separation plant to give greater throughput have been carried out. From the experimental caesium extraction plant eight sources totalling 9500 curies were despatched. The prototype plant is said to be difficult to operate.

ISOTOPES

Sales For the year, were £650,000 — £150,000 from Harwell, £500,000 from Amersham. This is 20 pc better than last year. Exports totalled 60 pc.

Imports Some isotopes were imported to make up loss due to Windscale accident.

Wantage The Wantage Radiation Laboratory came into operation. 23 cells are planned. Provision is made for two 10,000 curie cells, twenty 2000c and two 100c units for plant genetics. In addition a facility is being built for housing up to 3 million curies in the form of spent fuel elements.

New ideas A graft copolymer has been developed which can make nylon, terylene etc electrically conducting and thus dust- and dirt-resistant. Long-lived light sources using krypton 85 with a suitable phosphor have been developed. Leak detection in an underground coal gasification plant has been done using Kr-85.

FINANCE AND STAFF

Money Expenditure in 1958-9 for £105,744,010 was approved by Parliament in Feb 58 compared with the previous year's figure of £98,769,010. This includes a grant for the National Institute for Research in Nuclear science.

Men Total staff on March 31, 58, was 30,341 compared with 27,290 on April 1, 57. Break-down: non-industrial, 14,481; industrial, 15,860.

warm. He pointed out that the tradition up to now has been to cooperate informally rather than set up formal bodies. However, he added that 'this may change,' and threw out a hint that the matter might be discussed at the Commonwealth meeting in Montreal.

Nuclear Power Year Book

Nuclear power stations will soon have to take some share of peak loads and to do this capital costs must be brought down. The best way of achieving this is the development of hotter and more reliable fuel elements and 'relentless' research work must be directed to this end. This is a point made by Sir Christopher Hinton in a foreword to the second edition of the Nuclear Power Year Book, just published.

The Year Book has been completely revised from cover to cover and the contents have been considerably increased. The *Buyers' Guide* now lists 1500 firms and their products are arranged under 770 headings. The technical data section is increased in scope and now includes metallurgy while the isotope table is now the most up-to-date available. New review articles include ones on fuel element design and thermonuclear fusion.

CANADA

CANDU—decision in three years

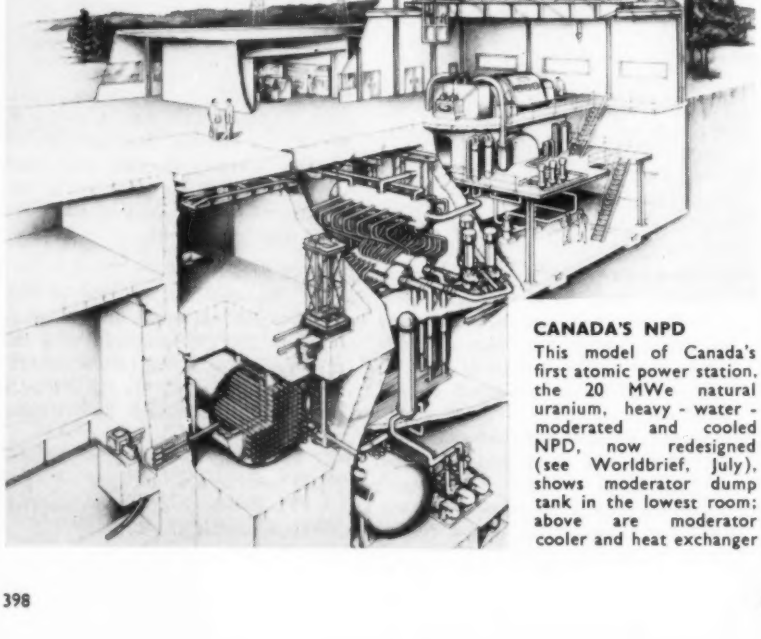
A burn up of uranium to 8000 MW days per tonne would be expected from the natural uranium, heavy-water moderated CANDU (Canadian deuterium-uranium) reactor, states the annual report of Atomic Energy of Canada Ltd. Advanced features now incorporated in the redesigned NPD will be included in the 200 MW project, and engineering development is now well under way. It is expected to take three or four years to complete. By that time a reliable cost estimate should be available and a decision would be taken on whether to embark on construction.

The 200 MWt NRU was operating successfully at the end of the period under review, says the report, and three major test loops are being installed. Two of them are water cooled and each will be able to cope with a heat output of 1·5 MW; the pressure tubes will be Zircaloy and will handle fuel assemblies 3¼in. dia and 10ft long. The third will be a gas-cooled loop designed for temperatures up to 1000°F.

GERMANY

New heavy water project

Germany may soon produce its own heavy water following a decision by Degussa of Frankfurt and Uhde of Dortmund to build a pilot plant. The two groups have been studying a process developed by Professor Dr E. W. Becker of Marburg; this makes use of the water-hydrogen exchange with the assistance of a highly dispersed catalyst in high pressure columns on the basis of a hot-cold process. Results are promising enough to warrant building a plant to get additional data with a view to eventual full-scale production. A spokesman for Degussa says experiments up to now show the method has 'distinct advantages' over others from the standpoint of economy.



CANADA'S NPD

This model of Canada's first atomic power station, the 20 MWe natural uranium, heavy-water-moderated and cooled NPD, now redesigned (see Worldbrief, July), shows moderator dump tank in the lowest room; above are moderator cooler and heat exchanger

ITALY

Nuclear forum set up

An Italian Forum for Nuclear Power has been set up under the Presidency of Sgr Martinoli, Director-General of AGIP Nucleare. It will aim at assembling representatives from the nuclear industry —both private and State-owned—and from universities and government organizations interested in atomic energy applications.

The managing committee includes Sgr Lolli, director of the Banca Nazionale del Lavoro, Luciano Orsoni, director of SORIN, and others in industrial, technical and professional fields. Their job will be to encourage nuclear enterprise in the economic interests of the country, to promote the spread of knowledge in the atomic field, to show the government the needs of those interested in starting atomic projects and to maintain liaison with international bodies.

RUSSIA

Accent on glamour?

A slow down in the nuclear power programme seems on the cards as the members of the State planning committees thrash out the details of the next seven-year plan. Little has been heard recently of the 2000-2500 MW nuclear capacity which was to be installed by 1960 and it seems likely that apart from developing a few glamorous items like atomic powered locomotives, the Russians will shelve the prospects of a really large-scale programme. Main emphasis of present proposals is on catching up with the West in electricity production by concentrating on the plants which can be built fastest. This would involve using conventional rather than atomic fuels.

In a speech at the dedication of the 2300 MW Kuibyshev hydroelectric plant, Krushchov spoke of the necessity for getting quick returns for capital invested. 'The building of some hydroelectric plants must be stopped for the time being,' he said. 'It would be faster to put up thermal stations and in the present conditions the most important thing is to win time.' This was 'more important' than the fact that thermal power would be more expensive. The speech, though an important one which showed several changes of thinking on electricity production, contained no reference to nuclear power.

The new seven-year plan will incorporate a considerable change in the structure of the fuel balance. In the postwar period, from about 1946 onward, coal constituted 80 pc of the fuel consumption and oil accounted for the remainder; no natural gas was used. Following recent discoveries of gas and oil deposits

output of these two fuels is planned to rise steeply until they form 63 pc of the total after fifteen years. Figures quoted by Krushchov in his report at the anniversary session of the Supreme Soviet were 270,000 million cubic metres a year of gas, 350 million tons of oil and 650 million tons of coal. In the long run this policy is hoped to produce large economies. An estimate by I. I. Kuzmin, chairman of the USSR State Planning Committee, in an article in the magazine of the Academy of Sciences, gives 36,000 million roubles as the saving which would result in 1972 with the new fuel balance. Total savings in the next fifteen years would be about 240,000 million roubles, he thought. His article surveyed future plans in all the maior industries but the only specific nuclear proposal was the development of an atomic locomotive.

—UNITED STATES—

Only 56 pc pass AEC check

Five per cent of the inspections carried out by the Atomic Energy Commission in the last six months have revealed potential or actual radiation hazards, discloses the Commission in its semi-annual report. Of the organizations engaged on nuclear work which have been inspected nearly 6 pc have failed to maintain proper procedures or equipment in cases 'that have direct bearing on the safety of operations' and only 56 pc passed with a completely clean bill. During 1957 accidents involving exposure of workers to radiation above the AEC's safety level occurred in about 28 organizations.

Uranium Ore production totalled about 2·5 million dry tons during the last six months as compared to approximately 2 million in the previous six months. Imports of uranium oxide from Canada went up from 3850 to 5730 tons, and it is expected that a figure of 6800 tons will be reached for the last six months of this year.

Isotopes Indicating further growth in uses of isotopes for medical and industrial applications, the number of licences increased from 3335 at November 30 to 3750 by May 31. Licences for medical uses accounted for 39 pc of the increase.

Reactors 111 operations' licences were issued, bringing the total to 259 by June 30.

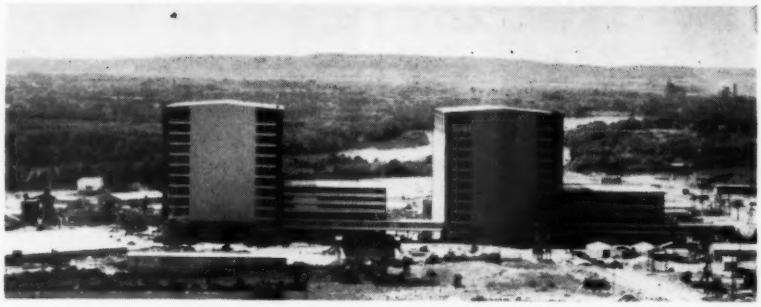
Nuclear material Sixty-three licences for possession and use of nuclear materials were granted. These were chiefly for small quantities to be used for research purposes and did not include any for fuel in licensed reactors.

Peaceful bomb uses Explosive nuclear devices are being tried out for excavation, power production, isotope production, mining (breaking up underground deposits) and recovery of oil from shales, tarsands and depleted wells.

Technical manpower A survey showed a total of 13,500 nuclear scientists and 18,750 nuclear engineers at the end of last year in industry, educational institutions and the AEC. Of these the Commission and its contractors employed about 68 pc, private industry 18 pc and the remainder were in college and university atomic energy activities.

SGR coolant for irradiation?

The possibility of using the sodium reactor coolant at the Hallam Nuclear Power Facility as a high-level radiation source for industry will be studied by Atomics International, following the award of a contract by the AEC. The agreement is on a cost-type basis with a fixed ceiling of $76,000. The study will investigate the technical feasibility of using the radioactive sodium coolant for industrial radiation processing and of integrating such a radiation processing plant with the Hallam facility. Included will be a preliminary design study for the radiation processing plant. The 75 MWe facility at Hallam is being built by the Commission and the Consumers Public Power District under the AEC's power demonstration reactor programme. Construction started in June and is expected to take three and a half years.



G2 goes critical at Marcoule

Two years after G1, France's second power reactor, the natural uranium graphite-moderated, gas-cooled G2 (top left) has started up. By the end of the year—when the similar G3 is due critical—the plant is expected to produce plutonium at an annual rate of 40 kg and give 30 MW of electricity. The total fuel charge will be 115 tonnes of natural uranium contained in 36,000 cans each 30 cms long in the 1200 horizontal channels in the moderator. This forms a horizontal cylinder 8·45 metres long and 7·8 in diameter, including the reflector, and contains 1271 tonnes of graphite.

—INTERNATIONAL—

Cut down exposure—UN report

All steps designed to minimize irradiation of human populations will act to the benefit of human health. Such steps include the avoidance of unnecessary exposure resulting from medical, industrial and other procedures for peaceful uses on the one hand, and the cessation of contamination of the environment by explosions of nuclear weapons on the other. Such is the disappointingly vague general conclusion of the United Nations' Scientific Committee on the Effects of Atomic Radiation contained in its 228-page report, published on August 10.

Throughout the report are frequent allusions to the lack of knowledge of the biological process involved and the absence of adequate data from which to draw conclusions. It is now agreed that there is a threshold dose for somatic effects but until the influence of delayed effects is known more accurately the Committee were unable to give the threshold a definite figure. On genetic effects it is accepted that radiation-induced mutations are harmful and increase in direct proportion to the dose—between 10 and 100 rads per generation would probably be required to double the natural mutation rate in humans.

The 15-nation Committee was set up by the General Assembly in December 1955 and it first met in March 1956. The

only serious disagreement seems to have been in drafting the general conclusions quoted above. The Soviet Union wanted a definite recommendation included for the ending of weapon tests but this was voted out and included only as a minority report.

Reaction of the British Medical Council, published as a white paper on August 15, was that little had been added to the conclusions reached by the BMC in 1956, though these had been 'strengthened and amplified.'

IAEA names safeguards chief

The man chosen to work out the details of the International Atomic Energy Agency's safeguards system is Roger M. Smith, formerly superintendent of Atomic Energy of Canada's production planning and control branch. The safeguards are intended to prevent the use for military purposes of nuclear material or equipment supplied by the Agency or under its control. The problem of an inspection system has cropped up recently in several proposed bilateral agreements for the sale of reactors and fuel. The US-Euratom pact is an example and Congress is still not happy about relinquishing inspection rights. Many countries are looking to the IAEA for a lead and any system which the Agency develops will have considerable influence. Among Roger Smith's responsibilities will be procedures for accountability, storage and inspection of atomic material and equipment. His Division of Safeguards is expected to maintain a continuous review of these procedures in the light of technological developments and experience and undertake or encourage research into more efficient safeguards standards, methods and policies.

Mr Smith has been with Atomic Energy of Canada since 1946 and has worked on both the operational and administrative sides.

IAEA—the first six months

A stock-taking of the International Atomic Energy Agency's first 8 months of operation is contained in the report the Board of Governors is presenting to the second session of the General Conference, which meets in Vienna on September 22.

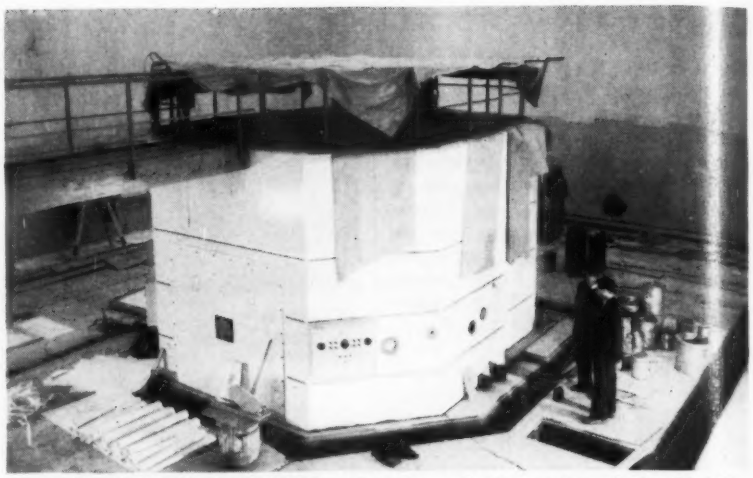
Fissionable materials Backing up national programmes with a guaranteed supply of fuel is the IAEA's major role and fissionable materials offered to the Agency so far amount to 5140 kg of contained uranium 235; adequate supplies of natural uranium and thorium are also promised. But no country has yet asked for fuel and in any case none can be given until the Agency signs agreements with the countries offering it. Conclusion of these will depend on how much the Agency is prepared to pay for the fuel and negotiations are in progress with the countries concerned.

Technical assistance Efforts have been made to build up a consultant service of experts and the US and USSR have each offered the services of 20-30 scientists. The response of the rest of the world has been limited to 5-10 from France, 2 from Japan, and statements by the UK, India and South Africa that they will 'endeavour' to make experts available in special fields on request. However the first team in operation, which went to survey Latin America's education and training needs, included a British expert—Harold Sheard from AERE, Harwell—as one of its three specialists.

Exchange of scientists The major technical asistance activity already in operation is the international training programme. Reason is that this can be started straight away even with the Agency's limited funds and experience. 268 subsidized or fully paid fellowships for training or research had been offered by member countries up to June 30 and 140 of these are available this year.

Health and safety First priority in the programme to produce a wide range of safety codes has been given to the safe packaging, transport, use and disposal of radioisotopes. A provisional manual is being prepared with the assistance of a panel of experts headed by Dr Gunnar Randers of Norway.

Isotopes and research Plans are under way for the formation of special isotopes teams; these will be sent on request to help underdeveloped areas decide how isotopes can best be used in meeting their research and development problems. A committee is going through national and commercial catalogues with a view to compiling an international isotopes catalogue. The report also lists limited research contracts such as that placed with the Vienna University Chemical Institute (*Worldview* July).



BERLIN REACTOR COMPLETED Technicians finish erection of the 50 kW US Atomics International pool-type reactor at the Institute for Nuclear Research in West Berlin. Shipped from California and assembled here it is the fifth to be sold overseas by AI, the others being in Tokyo, Milan, Risö and Frankfurt

WORLDBRIEFS

- **France** The death occurred in a Paris hospital on Aug 14 of Prof Frédéric Joliot-Curie (58). He gained the Nobel Prize for Physics in 1935 for his discovery with his wife, Irène, of artificially-induced radioactivity. Joliot-Curie was the first high-commissioner of the Commissariat à l'Energie Atomique, a post which he held from 1946 to 1950.
- **United States** A combined streptomycin and bone marrow injection treatment developed by Argonne's biological and medical research division is reported to have cut deaths of neutron-irradiated mice by 85 pc.
- **United States** Engineering studies on a nuclear seaplane project at the Martin Company's Baltimore division have been extended by a new $385,000 navy contract.
- **United States** The *Nautilus*, which arrived at Portland, UK, on August 12, after the first underwater crossing of the North Pole, used three separate navigation systems: an inertial guidance system made by North American Aviation and two using information provided by Sperry Gyroscope Co equipment.
- **Great Britain** Goods freed from embargo on August 12 for export to communist countries include most vacuum pumps, electrical generating machinery, motors and turbines.
- **Norway** The team working on the Halden boiling heavy water reactor will be aided by James A. Deshong, head of the control section of US Argonne's Reactor Engineering Division, who is to spend six months at Halden.

On the eve of Geneva
Britain's chief delegate
highlights the programme

The nuclear sciences and our civilization

by Sir JOHN COCKCROFT O.M., F.R.S.

Member for research, United Kingdom Atomic Energy Authority

WHEN THE FIRST Geneva Conference on the Peaceful Uses of Atomic Energy was held in 1955 I was bold enough to deliver an address on the future of atomic energy. Three eventful years of rapid progress have passed since then and the wide variety of information which will be presented during this year's conference will show what an important part the nuclear sciences are playing in the development of our present civilization.

Growth in energy demand

Economists and statisticians at the meetings in 1955 made predictions of the growth which could be foreseen in the world's total energy requirements, which they said would increase by about one and a half times by 1975. During the period since then the United Kingdom, faced with possible fuel imports of as much as £M350 without nuclear energy, has trebled its initial atomic power programme and is already well under way with the construction of four large stations. The countries of Euratom, realizing that their increased energy requirements could otherwise mean huge increases in their import bills, have prepared a target plan for 1967 of 15,000 megawatts of nuclear power and would expect to save 100 million tons of coal equivalent a year by 1975, by which date we in the United Kingdom may be saving the equivalent of 40-50 million tons of coal.

In other countries, preliminary construction work has already started on the first large station in Italy, and Japan, whose situation is similar to that of Western Europe, has indicated its intention of starting on a programme in the near future. These developments have followed our expectations that the first practical use of nuclear power would be in the more highly industrialized countries which have reached the limit of their coal production, and we expect that by 1965 there will have been a number of other programmes started in these countries and that it will become more attractive to other countries as the nuclear costs fall from that time onwards.

Nuclear ships

Progress is also being made in the application of nuclear power to ship propulsion and to the smaller land stations. The United States has plans for a very large nuclear powered Navy. The USSR has gone ahead with the construction of a nuclear propelled ice-breaker. In Britain, although it will not be long before we have a naval vessel of this type, the development of commercially economic vessels is engaging a great deal of attention. No great turnover to commercial nuclear propulsion can, I would say, be expected till the 1970's.

It was at the 1955 conference that the possibility of controlling thermonuclear reactions was first aired in public and the work which has proceeded in a number of countries will undoubtedly provide some of the most interesting talking points of the conference. It is natural to expect that reports on the American, British and Russian work will receive considerable attention, but contributions will also come from nine other countries.

Even this will be only one of the many intensely interesting aspects of the peaceful development of atomic energy which will be discussed. Over two thousand papers have been submitted and although not much more than a quarter of these will be read it will still be necessary to hold five parallel sessions. The programme has been prepared by the Secretary-General of the conference, Dr S. Eklund, with the aid of a scientific secretariat, and on the advice of the United Nations International Advisory Committee, whose members are drawn from seven countries. The first four days of the conference are to be devoted largely to general sessions with papers suitable for a general audience and it is after that that it will split into five sessions. In addition to power reactors and fusion research these will cover reactor physics and reactor technology, basic physics in nuclear energy, basic chemistry in nuclear energy, chemical effects of radiation, method of separation of isotopes, processing of irradiated fuels and wastes, uses of isotopes, biological effects of radiation, production of nuclear metals, properties of reactor materials, and matters relating to health and safety. One of the really valuable features of the first conference was the opportunity given for informal discussions and time has been left in the programme for more of these to take place this time. There will also be a number of evening lectures suitable for a general audience.

Geneva's exhibitions

Associated with the conference will be a scientific exhibition and a prefabricated building has been erected in the grounds of the Palais des Nations to accommodate this, with the intention of illustrating the papers presented at the conference. There is also to be a commercial exhibition in the city, organized by industrial organizations of interested countries, and this will no doubt cover the field of nuclear power stations, research reactors, instrumentation, isotopes and other products now available for purchase.

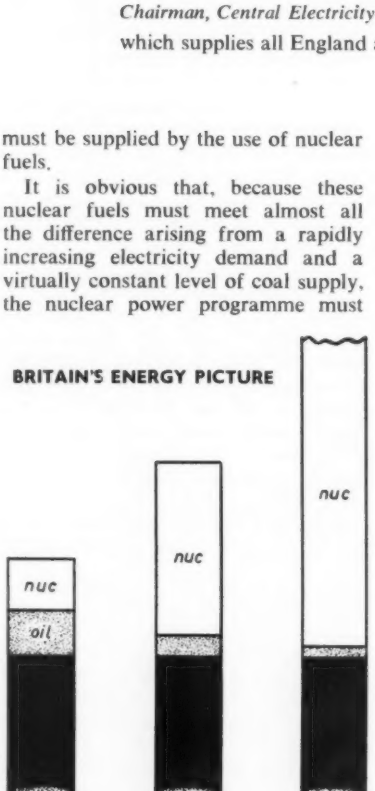
Background for Message: to

AT HOME
What atomic power has to do

by SIR CHRISTOPHER HINTON
Chairman, Central Electricity Generating Board
which supplies all England and Wales with electric power

THE DEMAND for electrical power in this country is doubling every ten or twelve years. The requirement of fuel for power stations increases at a slightly slower rate because the efficiency of conventional power stations is increasing but, having made allowance for this and for the fact that the rate of increase in demand may be reduced as time goes by, the estimated requirement of fuel (as coal equivalent) for the Central Electricity Generating Board's generating stations is 65 million tons in 1965 and this rises to 80 million tons in 1970. Whatever disagreement there may be between various authorities as to the rate of increase of coal production, there would be universal agreement that this quantity of coal will not be available; a reasonable estimate of the coal available for power station use in the period 1965 to 1970 is around 50 million tons a year. The deficit in fuel supplies for electricity production is therefore about 15 million tons in 1965 and 30 million tons in 1970. Some of this shortfall will be made good by the use of oil for electricity production but too great reliance on this imported fuel would obviously be inadvisable. If no further power stations are equipped for oil burning the consumption of oil (expressed as coal equivalent) will be about 7 million tons in 1965, falling to 3 million tons in 1970. The balance of requirement amounting to 8 million tons a year in 1965, 27 million tons in 1970 and thereafter increasing rapidly, must be supplied by the use of nuclear fuels.

It is obvious that, because these nuclear fuels must meet almost all the difference arising from a rapidly increasing electricity demand and a virtually constant level of coal supply, the nuclear power programme must expand rapidly from 1965. Wise expansion of any new technology is always exponential in form; it would be unwise—even if it were possible—to aim at a nuclear programme which brought industrial reactors into use for the first time in 1965 when the coal shortage becomes obvious and which from that date onwards builds them at the rapid rate which is required to meet the increasing coal shortage. The wise programme is one which builds up gradually to the required rate of construction in the middle 1960's and it is primarily for this reason that the construction of nuclear reactors for the Central Electricity Generating Board is already in hand. It should not be imagined that the reactors which are now being built are more economical than the conventional power stations which are being constructed today; they are in fact a little less economical even when they are given the benefit of operating entirely to meet base load requirements. With experience the capital and operating cost of nuclear power plants can be brought down but this could not be achieved simply by building experimental reactors; experimental work and industrial application must run hand in hand. The nuclear power plant industry must be built up so that it can meet the national demand from 1965 onwards, and this longer term objective must always be remembered by those who are responsible for all phases of the present ambitious programme.



Coal for power stays at 50M tons/year: demand doubles every 10 or 12

the Geneva Conference

NUCLEAR POWER

ABROAD
What British Industry is doing

by W. K. G. ALLEN

Chairman, Nuclear Energy Trade Associations' Conference

which organized the British section of the Atoms for Peace Exhibition

THE ONE HUNDRED AND EIGHTY British papers to be presented at the 2nd United Nations Conference on Atomic Energy will illustrate the rapid and significant progress made in Great Britain in the three years since the first Conference.

The eighty-four British participants in the concurrent commercial *Atoms for Peace* Exhibition will show that British industry welcomes inquiries for the design and construction of nuclear power stations of large or small generating capacity, research reactors, processing and handling plants, and the whole range of ancillary nucleonic and electronic equipment which is required for atomic energy plants, hospitals, research laboratories, and industrial plants of all kinds.

Firms' continuous history

Naturally the first and foremost evidence of the industry's serious interest in the export market is the action taken by individual manufacturers in promoting the sale overseas of their products — through their established associates and agents in other countries and by direct approach. Almost all of the thousand British engineering firms engaged in the production of nuclear equipment have manufactured and traded for many years—some have a continuous history of progress over a hundred years or more. In the case of those firms which have grouped themselves together, as a consortium, under a new title for the purpose of promoting the nuclear side of their businesses, the component members of the group have been in business for a long time.

British engineering firms—on an average—export one-third of their output. Well established overseas—especially with regard to the non-nuclear side of their manufactures, and with knowledge and experience of the special requirements of the markets of the world—they are naturally in a good position to give expert advice and attention to those in other countries wishing to purchase nuclear equipment.

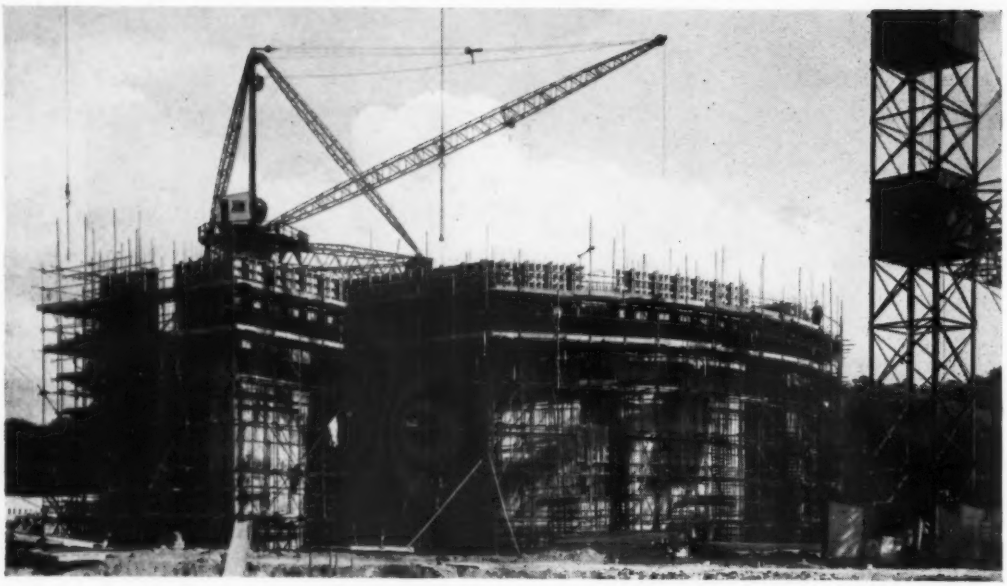
The future for British exports

British exports of nuclear equipment may be expected to grow quickly, and are likely to reach a total value of £M500 by 1966. This figure may appear large until looked at in relation to an engineering industry employing 3 million and with an annual output of £M5,000. Only a relatively small proportion of this output would relate to nuclear equipment, but this impressive figure provides an indication of the capacity of an industry well equipped to anticipate and to meet, in its stride, the changing requirements of its customers. These requirements will range from nuclear power reactors to nucleonic instruments. Already some have been met. For example, orders for high-flux research reactors have been received from Australia, Denmark and Germany. Last year, British electronic equipment to a value of £M6 was exported, over one half of which was supplied to the USA. A proportion of this equipment comprised nucleonic instruments for reactors and for utilizing British radioactive isotopes—now exported to fifty-two countries.

Importance of Government Agreements

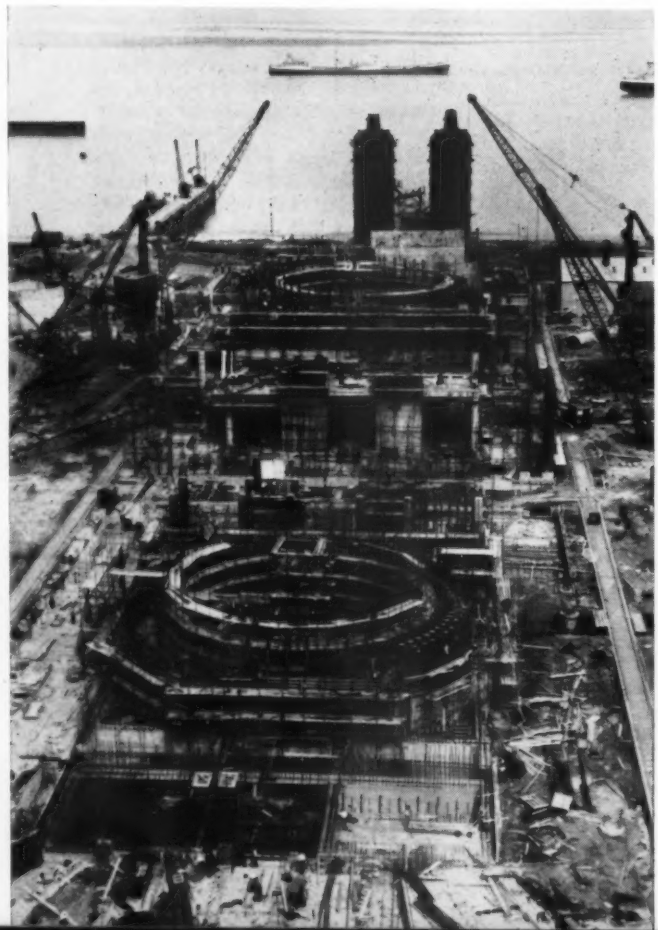
Significant export orders for British nuclear power station equipment are foreseen. A growing number of countries are interested in buying such equipment. Japan has stated that she will purchase a British power reactor. An agreement has been signed between a British firm and Italian organizations, which covers mutual co-operation in the building in Italy of nuclear power stations. Bilateral agreements between the British and certain foreign Governments for the supply of nuclear fuel have been completed. Western Europe promises to be a good competitive market for nuclear power plant, and it is noteworthy that negotiations between the UK Atomic Energy Authority and Euratom have begun.

British firms are well aware that requirements will vary from country to country, and have thus made provision to meet many different needs for nuclear power plant—from the execution of a complete 'turnkey' job to the granting of licences to manufacture. All these developments will be seen in the British section of the exhibition.



HUNTERSTON, Ayrshire. Walls have reached level of shielded chamber in which the fuelling machine will operate below the spherical reactor shell

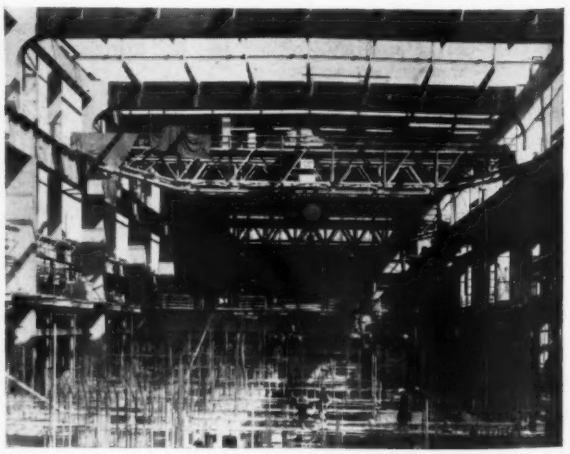
Only a planner's dream at the time of the first Geneva Atoms for Peace Conference, Britain's four commercial power stations are now rising fast round the shores of England and Scotland. These stations between them will generate about 1400 megawatts: two more, to be started next year, will add 1000 to this figure. Aim is 6000 MW nuclear by 1966. All have two natural-uranium, graphite-moderated, gas-cooled reactors of the Calder Hall type but of greatly increased output and rating.



Building atomic energy

PROGRESS AT THE PO

BRADWELL, Essex. Installation of spherical reactor vessel in No 1 reactor has started inside biological shield. Boilers arrive towed by tugs every six weeks—since this photo another has gone up. In turbine hall (below) foundations are nearly ready for the six 52 MW turbogenerators



BERKELEY, Gloucestershire. Reactor vessels are being assembled inside the biological shield and boilers are rapidly being erected round No 1 reactor. Between reactors is cooling pond. Left, the turbine house is already weathertight and work is advanced on the sea-water pumphouse connecting with the tunnel leading to the Severn estuary

POWER STATIONS

HINKLEY POINT, Somerset. The biggest of the four and the latest to be started. From January to July 13,000 cubic yards of high quality concrete had been placed in the shield and foundations. In foreground is a base for one of the gas blowers

GINO MARTINOLI
Director-General, AGIP Nucleare, Milan

and

DAIGORO YASUKAWA
President, The Japan Atomic Power Co., Tokio

In exclusive messages to NUCLEAR POWER, say

'Why we chose the gas-cooled reactor for our first nuclear power stations'

'We need power now'
by GINO MARTINOLI

DURING THE PERIOD immediately after the second war, Italy was fully engaged in its own reconstruction problems and unable to devote much effort to the study of peaceful uses of nuclear energy. In 1952, however, CNR (Consiglio Nazionale delle Ricerche) created CNRN (Comitato Nazionale Ricerche Nucleari) but even in 1956 it only succeeded in getting government support of about 3000 million lire (£M1·7). After the first Geneva conference Italian industry began to take an interest in these problems and it was realized that an inadequate development of power resources would hinder the country's economic growth, since the demand was estimated to double in the next ten years.

During the period 1958-1967 we expect to build in Italy power stations with a capacity approximately equal to the total now installed. Briefly, we have to carry out, in ten years, the amount of work done in the last 75 years. Up till now, hydroelectric stations have been the largest source of power, producing up to 90 pc of our needs. Unfortunately, hydro resources are now nearly exhausted and the installed cost per kW is no longer economic. Italy has no appreciable resources of coal and our natural gas reserves are too valuable industrially to be used for producing power. The oil fields, whilst interesting, cannot make any substantial contribution to our needs. It is therefore estimated that, in 1967, in order to meet our requirements, it will be necessary to increase the value of our oil imports by 150,000 million lire (£M85) yearly.

Unsolved problems

In a situation very similar to that of Great Britain and Japan, nuclear power soon attracted the attention of responsible Italian leaders. We must admit, however, that electric power from nuclear sources still presents unsolved problems. American salesmen claim that industrial and economic problems have been overcome and that the same guarantees can be given for a nuclear station as for a conventional one. It seems, however, still very difficult for an electrical utility industrialist to take a decision between nuclear and conventional methods of power production.

In Britain, only one type of reactor, among the many possible, was selected for construction and four large consortia developed their designs from the famous and unique prototype, Calder Hall.

American industry, on the other hand, adopted a much wider approach, dispersing their own efforts in many directions. This has meant perhaps a slower achievement of positive results, but the vast amount of experience acquired will be very valuable in a later stage. Then nuclear power will no longer be faced with economic comparison with existing cheap power sources; it will become a vital problem of replacing ever-decreasing natural resources.

Due to the situation I have outlined, we do not possess sufficient laboratories, research facilities or technical staff to undertake such design and construction responsibilities, as are being faced by the major British and American consortia. Therefore, if we want nuclear power stations, we must rely on one of those groups for a 'turn-key' job. Even so, it is necessary to make a selection among different tenders and we must admit that we do not have much experience to make a reliable comparison.

American and British

At the end of 1956, the Italian Council of Ministers charged Mr E. Mattei, President of ENI (Ente Nazionale Idrocarburi), which controls a large part of Italian energy resources, to carry out a preliminary study on the utilization of this new source of energy. For this purpose, ENI formed AGIP Nucleare, which incorporated SOMIREN, a company whose object is research and mining of radioactive ores. At the same time, AGIP Nucleare, in association with IRI (25 pc holding), created SIMEA—a company to construct and operate a nuclear power station in Southern Italy, thus contributing to the industrialization of this underdeveloped area. AGIP Nucleare began to study the types of reactors offered by the British consortia, whilst SIMEA carried out a similar study on those American reactors which showed immediate practical industrial possibilities, namely PWR and BWR. Later, due to the lack of trained engineers rather than to financial limitations, the management of ENI decided to give priority to only one plant, to be erected as soon as possible in the area between Rome and Naples.

Examination of tenders submitted both to AGIP Nucleare and SIMEA showed that enriched uranium reactors were developing and improving so quickly that it was difficult to enter

into a definite contract without more time for the designs to stabilize. But they should be taken into consideration for a future stage of our development programme. This programme, tentatively sketched by CNRN, foresees nuclear stations generating about 2000 MW in the next ten years.

Italy's first nuclear station

The choice between the tenders of the four British nuclear consortia, similar in many aspects, was very difficult and necessarily a compromise between various technical, commercial and financial considerations. It would have been almost impossible if the UKAEA had not assisted and helped us in a fair and impartial way. In May 1958, we entered into a long-term technical cooperation agreement with the Nuclear Power Plant Co and on July 1 preliminary work for a 200 MW station was started near Latina. AGIP Nucleare, as NPPC's exclusive licensee for Italy, are responsible to SIMEA, to complete and commission the station by July 1962.

The agreement enables AGIP Nucleare, with the advice and cooperation both of NPPC and UKAEA, to adapt designs to Italian requirements and to undertake responsibility for construction of nuclear power stations. Italian technicians will take an active part in the projects and so our share in design and construction of nuclear plants will increase, step by step, allowing us to build up the necessary industrial and technical background for the future. This approach appears to us preferable to having our needs fulfilled by 'turn-key' delivered plants. Only by assuming direct responsibilities and, if necessary, by making mistakes, can we learn and regain lost time. This kind of cooperation between British and Italian industry will bring many advantages to both countries.

'We had three reasons'

by DAIGORO YASUKAWA

THE ENERGY REQUIREMENTS of Japan have been increasing sharply with the development of modern industries and the rise in the living standards of the population. From the long term point of view, the demand in future is also expected to follow the similar trend of rapid increase. Supply of energy, on the other hand, will have to be increasingly dependent upon foreign countries as sources of supply of raw materials. This is due to the facts that development of economically advantageous sites in Japan for hydro power is becoming more difficult, whilst coal production for thermal power is approaching its limit because of our meagre deposits and worsening mining conditions. The oil production cannot be much relied upon because of poor potentiality.

The Japanese Government last year drew up The Programme for Long Range Development of Power Reactors, and emphasized the necessity of rapid development of atomic power generation. For this purpose the Government pointed out the desirability of importing at an early opportunity power reactors of commercial scope which are appropriate to the present-day conditions of Japan. Through the valuable experiences to be obtained in their construction and operation, domestic production of power reactors, as well as education and training of Japanese engineers are to be expected. Based on this fundamental policy of the Government, the Japan Atomic Power Company was established in November, 1957, enjoying full support from industrial, financial and scholastic groups of the country.

After thorough studies of different possibilities, the Company came to a conclusion that the power reactors to be imported for commercial uses shall be of two types, namely natural-uranium gas-cooled type and enriched-uranium water-cooled type. The Company intends to construct these two types of reactors in two stages. The first stage of construction was designated to be that of natural-uranium gas-cooled type. The main reasons for this decision are as follows.

1. EXPERIENCE. Operationally, the gas-cooled reactor is fully proven

Power reactors for practical uses are still in the initial stage of development and there are not very many such reactors now actually under operation or construction. Under such circumstances, if a power reactor for practical uses is to be imported and erected in this country—especially inasmuch as it will become Japan's first power reactor—it is requisite that a type which has achieved excellent results and which promises successful future development of atomic power generation in Japan should be selected.

The Calder Hall type reactor in the United Kingdom was completed in October, 1956 with the object of producing plutonium as well as electric power. It has yielded very good operating results and has had no serious accident so far.

The United Kingdom is now engaged in construction of the so-called 'advanced type' reactors of 300-500 MW electrical output, which have been developed from the prototype Calder Hall reactors.

Judging from the foregoing facts, the Company considered the natural-uranium gas-cooled type the most suitable and appropriate to be imported as Japan's first reactor for commercial use.

2. FUEL. Supply of natural uranium is easy and sure

In order to carry on atomic power generation smoothly, it is very important that the acquisition of nuclear fuel should not be interrupted because of changing international situations, and also that its supply be assured without undue difficulty and for a long period of time. Uranium to be used by the natural-uranium gas-cooled type reactor is produced extensively throughout the world. Japan, too, is expected to become capable of refining and processing uranium in the near future. On the other hand, production of enriched uranium is presently confined to specific countries of the world, and changing international conditions could make our access to it very difficult. From this point of view, the natural-uranium gas-cooled type reactor was considered more desirable of the two.

3. ECONOMY. The gas-cooled reactor is already almost competitive with conventional thermal plants

According to the information so far supplied from the United Kingdom, cost of electric power generation of the natural-uranium gas-cooled type reactor, if imported from the United Kingdom and constructed in this country, will be generally comparable to that of conventional thermal power plant. On the other hand, the enriched-uranium water-cooled type of reactor under the present stage of development is still accompanied by several uncertainties, especially with regard to the fuel cost. Although it can be expected that both the cost of construction and of fuel for enriched-uranium water-cooled reactors will come down in the near future to the point comparable to those of conventional thermal power plants, it is our consideration under the present conditions that the first power reactor for Japan should be natural-uranium gas-cooled.

British commercial nuclear power stations under construction

NAME OF STATION		BERKELEY	BRADWELL	HINKLEY POINT	HUNTERSTON
Operating authority		Central Elec. Gen. Board	Central Elec. Gen. Board	Central Elec. Gen. Board	S. Scotland Elec. Board
Main contractors		AEI-John Thompson Nuclear Energy Co Ltd	Nuclear Power Plant Co Ltd	English Electric, Babcock & Wilcox, Taylor Woodrow	The General Electric Co Ltd
Number of reactors		two	two	two	two
Gross max. power output	MWe	332	352	627	344
Net sent out power	MWe	275	300	500	300 (initially)
Date started/commissioned		Jan 57/mid-61	Jan 57/early-61	Sept 57/end-62	Oct 57/June 62
CORE					
Diameter by height (excl. reflector)	ft.	44 × 24	40 × 25·5	49 × 25	44·5 × 23
Overall graphite dimensions	ft.	48 × 30	45 × 31	—	50·5 × 28
Number of fuel channels		3275	2575	4500	3288
Lattice pitch	in.	8·00	8·00	7·75	8·25
Number of control rod holes		132	158	—	208
Total wt. of graphite	tonnes	2134	1910	2032	2180
FUEL ELEMENTS					
Uranium rod dia. × length	in.	1·1 × 19·2	1·155 × 36	1·1 × 36	1·15 × 24
Canning material		Magnox A12	Magnox A12	Magnox A12	Magnox A12
Method of support		graphite struts	stacking	stacking	individual, by graphite sleeves
Number per channel		13	8	8	10
Total wt. of uranium	tonnes	253	237·3	376	249
CORE PERFORMANCE (estimated)					
Maximum thermal flux	$n/cm^2/sec$	$2·14 \times 10^{13}$	$2·68 \times 10^{13}$	4×10^{13}	2×10^{13}
Maximum/average flux, radial		1·193	1·21	1·19	1·240
Maximum/average flux, axial		1·422	1·43	—	1·430
Temp. coeff. of reactivity (uranium)	per °C	$-1·9 \times 10^{-5}$	$-2·3 \times 10^{-5}$	—	$-2·1 \times 10^{-5}$
Temp. coeff. of reactivity (mod.)	per °C	-4×10^{-5} (fresh). 12×10^{-5} (cyclic)	$-4·4 \times 10^{-5}$ (fresh)	—	$-3·8 \times 10^{-5}$ (fresh). 10×10^{-5} (cyclic)
Total built in reactivity, cold unpoisoned	pc	4	4·9	—	4·5
Thermal rating (gross)	MW/tonne	2·19	2·24	2·53	2·15
Centre channel thermal rating	kW	202	—	258	201
Normal maximum can temperature	°C	424·5	—	430	454
Centre channel mass flow	lb/s	2·21	—	2·8	2·25
Inlet gas temperature	°C	160	180	180	204
Outlet gas temperature	°C	345	390	375	391
Total mass flow	lb/s	6360	—	10000	5900
Conversion factor		·832 initially	·826 initially	—	0·81 initially
Gross thermal power of reactor	MWt	555	531	950	535
CONTROL SYSTEM					
Total number of rods		132	120	—	164
Grouping		102 cont. 20 safety. 10 flux stab.	108 control, 12 shut-off	—	—
Amount of K controlled	pc	cont. 5. safety 1. flux stab. ·63	7·0 total	—	coarse 7·80, safety 0·50, fine 0·15
Length by dia.	ft. × in.	25·5 × 1·75	28 × 2·25	—	21 × 2
Construction		4·25 pc boron steel	boron steel	—	boron steel tubes
SHIELDING					
Thermal shield details		top 5 in. bottom 4 in. sides 1 in.	none	none	none
Biological shield details and dimensions	ft.	9 av.	9–10	7–9	sides 9, top 10·5 + 1·5, bottom 6·5
Cooling system		air, once-through induced draught	air, once-through, induced draught	air, once-through, induced draught	air, once-through, induced draught

CIRCULATORS					
Number per reactor		eight	six	six	eight
Type		axial, single stage horizontal	axial, single stage horizontal	axial, single stage horizontal	centrifugal, vertical shaft
Drive		ind. motor, fluid coupling	ind. motor, variable freq.	ind. motor, variable freq.	d.c. motor, merc. arc rectrs.
Speed range	rpm	5:1	600–3300	—	55–1100
Power input	MW	2·38	2·5 app.	4·1 app.	1·76
Mass flow	lb/s	820	877	1670 app.	750
Pressure rise	psi	7·34	7·6	—	7·6 max.
Temp. rise	°F	5·6	—	—	8
PRESSURE VESSELS					
Dimensions and form	ft	cylindrical. 50 × 80	sphere 66·75 i.d.	sphere 67 i.d.	sphere 70 i.d.
Thickness	in.	3	3 min.	3	2⅜ min.
Method of support		18 5-ft dia. roller supports	24 rocking columns	skirt	skirt
No of standpipes		193	256	200 app.	212 top, 101 bottom
Working pressure	psig	125	132	185	150
Material		Si-killed mild steel	low alloy steel	28/32 ton, Si-killed boiler plate	Coltuf 28
Max. working temperature	°F	572	716	650	450
HEAT EXCHANGERS					
Number per reactor		eight	six	six	eight
Dimensions of shell, dia. × ht.	ft.	17·5 × 70	19 × 92	21·5 × 90	19·5 × 73·5
Material		mild steel	—	28/32 ton, Si-killed boiler plate	silicon-killed carbon steel
Tube banks—details		s'htr, evap'r, econ'r for h.p. l.p.	s'htr, evap'r, econ'r for h.p. l.p.	s'htr, evap'r, econ'r for h.p. l.p.	s'htr, evap'r, econ'r for h.p. l.p.
Type of extended surface		s'htr plain, others integral fin	integral finned tubing	studded tube	continuous fins welded to tubes
H.P. steam pressure	psig	306	755	640	580
temperature	°F	612	707	686	700
flow	klb/h	139·8	170·8	293·3	143
L.P. steam pressure	psig	62	195	171	150
temperature	°F	612	707	660	660
flow	klb/h	64·7	87·5	166·7	71
Feed temperature	°F	170	190	162	296
PUMPS					
Boiler circulation, no. and type		2 h.p. and 2 l.p. glandless	2 h.p. and 2 l.p. glandless	2 h.p. and 2 l.p. glandless	2 h.p. and 2 l.p. glandless
Boiler feed, no. and type		6 a.c. main. 2 d.c. emergency	—	8 main, 2 emergency. Turbo type	8 + 2 aux. h.p. and l.p.
Circulating water, no. and type		6 cent. 58300 gpm	—	6 centrifugal, 96000 gpm	6 vert. spindle centrifugal
GENERATING PLANT					
Main turboalternators	number and MW	four. 83	six. 52	six. 93·5	six. 60
Alternators m.c.r.	MVA	104	65	110	75
Voltage	kV	11·8	11·8	13·8	11·8
Power factor		0·8 lagging	0·80 lagging	0·85 lagging	0·80 lagging
Revolutions	rpm	3000	3000	3000	3000
Stop valve steam H.P.	psig/°F	295/606 } at 80 MW	730/700	—	500/696
L.P.	psig/°F	57/600 } at 80 MW	180/700	—	138/654
Condensers Type		surface (3-shell, 2-pass)	2-pass	twin-shell, surface	2-pass regenerative
Flow Rate	klb/h	761	—	—	480
Vacuum	in. Hg	29·1	28·9	29	28·9
Circulating water	ton/h	717·4	—	—	13,500
Dump condensers, no. and type		2, jet	2	2, single shell, surface	2, single-pass regenerative
max. flow rate	klb/h	350	—	—	85 each
Auxiliary turbines (if fitted) no. & m.c.r.	MW	none	3 (1 spare) × 20·25	3 (1 spare) × 33	none

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Dimensions of shell, dia. × ht.	ft.	17·5 × 70	19 × 92	21·5 × 90	19·5 × 73·5
Material		mild steel	—	28/32 ton, Si-killed boiler plate	silicon-killed carbon steel
Tube banks—details		s'htr, evap'r, econ'r for h.p. l.p.	s'htr, evap'r, econ'r for h.p. l.p.	s'htr, evap'r, econ'r for h.p. l.p.	s'htr, evap'r, econ'r for h.p. l.p.
Type of extended surface		s'htr plain, others integral fin	integral finned tubing	studded tube	continuous fins welded to tubes
H.P. steam pressure	psig	306	755	640	580
temperature	°F	612	707	686	700
flow	klb/h	139·8	170·8	293·3	143
L.P. steam pressure	psig	62	195	171	150
temperature	°F	612	707	660	660
flow	klb/h	64·7	87·5	166·7	71
Feed temperature	°F	170	190	162	296
PUMPS					
Boiler circulation, no. and type		2 h.p. and 2 l.p. glandless	2 h.p. and 2 l.p. glandless	2 h.p. and 2 l.p. glandless	2 h.p. and 2 l.p. glandless
Boiler feed, no. and type		6 a.c. main. 2 d.c. emergency	—	8 main, 2 emergency. Turbo type	8 + 2 aux. h.p. and l.p.
Circulating water, no. and type		6 cent. 58300 gpm	—	6 centrifugal, 96000 gpm	6 vert. spindle centrifugal
GENERATING PLANT					
Main turboalternators	number and MW	four. 83	six. 52	six. 93·5	six. 60
Alternators m.c.r.	MVA	104	65	110	75
Voltage	kV	11·8	11·8	13·8	11·8
Power factor		0·8 lagging	0·80 lagging	0·85 lagging	0·80 lagging
Revolutions	rpm	3000	3000	3000	3000
Stop valve steam H.P.	psig/°F	295/606 } at 80 MW	730/700	—	500/696
L.P.	psig/°F	57/600 } at 80 MW	180/700	—	138/654
Condensers Type		surface (3-shell, 2-pass)	2-pass	twin-shell, surface	2-pass regenerative
Flow Rate	klb/h	761	—	—	480
Vacuum	in. Hg	29·1	28·9	29	28·9
Circulating water	ton/h	717·4	—	—	13,500
Dump condensers, no. and type		2, jet	2	2, single shell, surface	2, single-pass regenerative
max. flow rate	klb/h	350	—	—	85 each
Auxiliary turbines (if fitted) no. & m.c.r.	MW	none	3 (1 spare) × 20·25	3 (1 spare) × 33	none

British research and testing reactors available for export

NAME OF REACTOR		MERLIN	DIDO	PLUTO
Location		Aldermaston	Harwell	Harwell
Owners		AEI Research Laboratories	UK Atomic Energy Authority	UK Atomic Energy Authority
Main contractors		Associated Electrical Industries	Head Wrightson Processes Ltd Ministry of Works	Head Wrightson Processes Ltd Ministry of Works
Date in operation		crit. '58 fully op. '59	Nov. 1956	Oct 1957
Type of reactor		heterogeneous, thermal	heterogeneous, thermal	heterogeneous, thermal
Thermal power	MW	5 max. 1 normal	10	10
Moderator		water	heavy water	heavy water
Primary coolant		water	heavy water	heavy water
Primary coolant flow	gpm	1600	4300	4300
Secondary coolant		water	water	water
FUEL ELEMENTS				
type		plate, U-Al alloy, Al-clad	plate, U-Al alloy, Al-clad	plate, U-Al alloy, Al-clad
no. of plates per element		14	10	10
no. of elements		25 normal	25 max.	26 max.
U235 per plate	kg	10	100	100
enrichment	pc	93	93	93
minimum critical mass	kg	2·66 3·5 normal	—	—
CONTROL SYSTEM				
coarse control		1 cadmium, s.s. clad	6 signal arm	7 signal arm
fine control		1 stainless steel	1 vertical rod	1 vertical rod
safety control		2 cadmium, s.s. clad	—	—
Reflector		H_2O or BeO	D_2O and graphite	D_2O and graphite
Shielding		lead and barytes conc.	barytes conc.	barytes conc.
Max. neutron flux				
thermal	$n/cm^2/s$	10^{13}	10^{11}	10^{14}
fast	$n/cm^2/s$	4×10^{13}	—	—
EXPERIMENTAL FACILITIES				
Thimble holes	horizontal	8	20	nil
	vertical	3	28	14
Through holes	horizontal	2	3	4
Vacant lattice positions		1 in centre	—	—
Thermal column		2	5 ft × 5 ft	none
Other facilities		shelf	—	—
OTHER SIMILAR REACTORS COMPLETED, IN CONSTRUCTION OR ON ORDER		1 for Atomic Weapons Research Establishment (UK) and 1 for Land-Government Rhine-Westphalia (Germany)	HIFAR, in operation at Lucas Heights, Sydney, Australia, and 1 for Land-Government Rhine-Westphalia	DMTR in operation at Dounreay (UKAEA); and DR3 in construction at Risö, Denmark.

Other United Kingdom Atomic Energy Authority reactors

INDUSTRIAL GROUP

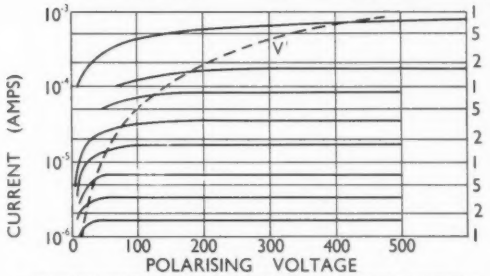
	DATE FULL COMMISSION	NUMBER OF REACTORS	TH. OUTPUT EACH. MW	ELEC. POWER GROSS. MW	
Calder Hall A	Feb 57	2	82	92	all eight reactors are identical natural-uranium, graphite-moderated, CO_2-cooled. Main purpose; Pu production, but each produces about 37 MWe net
Calder Hall B	Sep 58	2	82	92	
Chapelcross	Sep 59	4	82	184	
Windscale	1950	2	Air-cooled, Pu-production reactors. No. 1 written off as result of fire in Oct 57. No. 2 shut-down pending decision on its future		
Dounreay (DFR)	1959	1	60	15	fast breeder power expt. Highly enr. U or Pu, NaK cooled

RESEARCH GROUP

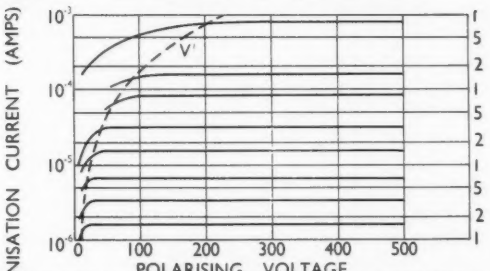
AERE, Harwell	DATE	FLUX	MODERATOR	COOLANT	FUEL	PURPOSE
GLEEP	1947	$3·7 \times 10^{10}$	graphite	air	Nat U	routine graphite tests
BEPO	1948	2×10^{12}	graphite	air	Nat U	isotope prod. and gen. (6 MWt)
ZEPHYR	1954	8×10^{8}	none	none	Pu	fast reactor studies
DIMPLE	1954	10^{8}	D_2O	none	varies	thermal reactor studies
LIDO	1956	10^{12}	H_2O	H_2O	en. U	shielding, etc.
NERO	1957	10^{8}	graphite	none	en. U	adv. graphite-mod. studies
NEPTUNE	1957	10^{8}	H_2O	none	en. U	PWR studies
HAZEL	1958	10^{6}	D_2O	none	U. fluoride	Homogeneous studies
AEE, Winfrith Heath						
HTGR	1959	—	graphite	N_2	en. U	temps up to 700°C

Type PNI
1025

NEUTRON DETECTORS FOR REACTOR CONTROL



SATURATION CHARACTERISTICS OF IONISATION CHAMBER PNI. 1026 FILLING: HYDROGEN 225 cm Hg



SATURATION CHARACTERISTICS OF IONISATION CHAMBER PNI. 1026 FILLING HYDROGEN 75 cm Hg

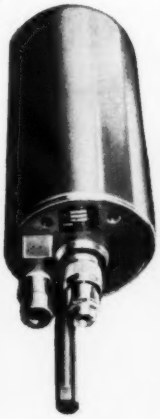
These two new units which have been specially designed for operation at high temperatures are now readily available. Designers and Engineers desiring further information should write for Data Sheet No. PNL 101.

OTHER PLESSEY NUCLEONICS ACTIVITIES INCLUDE:
Burst Fuel element detectors, flux scanning systems, health instrumentation including reactor effluent monitoring systems, pulse amplifiers, DC amplifiers, ratemeters, reactivity meters, installed test equipment and power units.

PLESSEY NUCLEONICS LIMITED
Weedon Road, Northampton. Tel: Northampton 4966

One of the **Plessey** Group of Companies

Overseas Sales Organisation:
Plessey International Limited,
Ilford, Essex, England

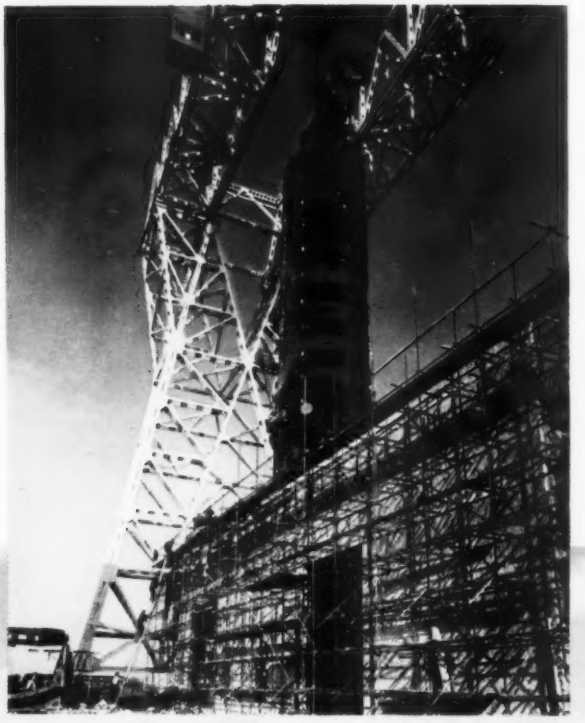


Type PNI
1026

PNL4

Tick **No 74** on reply card for further details

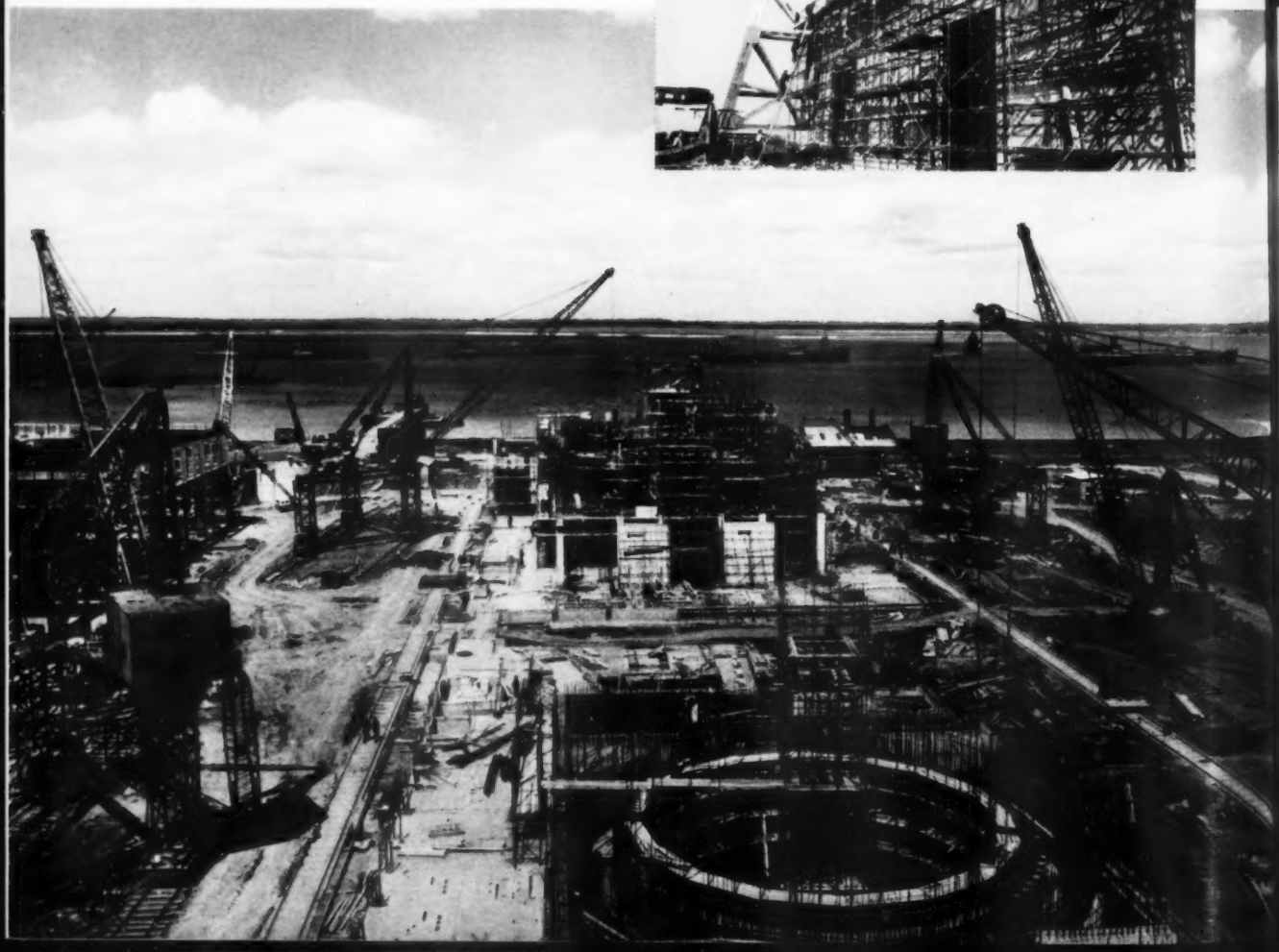
BRADWELL...



A boiler arriving at Bradwell site ▲

Installing a boiler in place — No. 1 reactor ►

The two reactors at Bradwell. To the left is the turbine hall ▼



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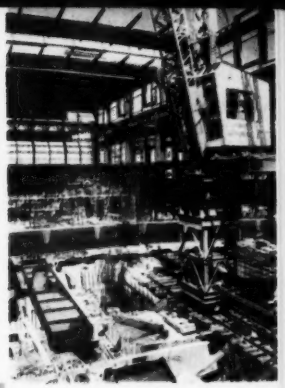
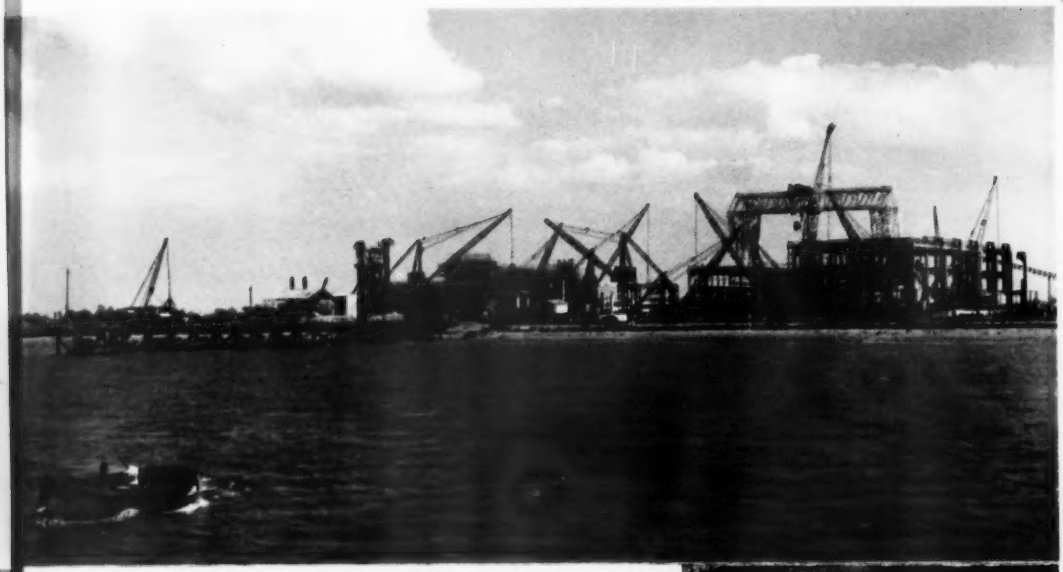
in a second year of progress





▲ *Structural steelwork the turbine house*

◀ *Bradwell site from Blackwater Estuary*

◀ *Looking down into N reactor*

▼ *A welder at work No. 1 reactor pres. vessel*

The Bradwell skyline has been completely transformed since work started on the world's first 300 Megawatt Nuclear Power station in January 1957.

This great project is being undertaken by The Nuclear Power Plant Company Limited which combines the resources of eight specialist firms. Their individual skills are co-ordinated into a unified team capable of undertaking the construction of complete nuclear power stations anywhere in the world.

The Bradwell story underlines the remarkable British lead in the practical application of Nuclear Energy and the NPPC is proud to be entrusted with this great contract by the Central Electricity Generating Board.

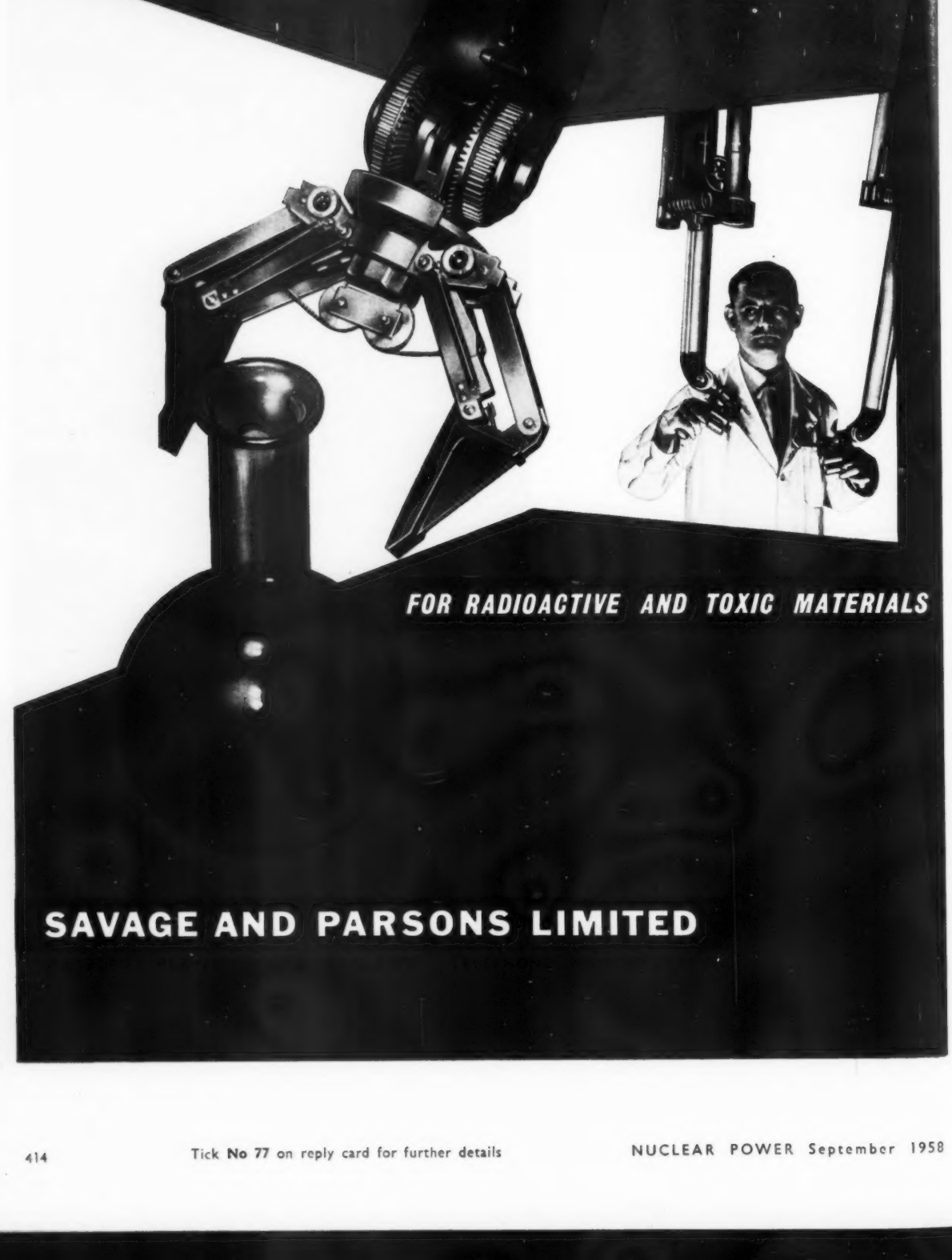
A Greater Britain Through Nuclear Power.

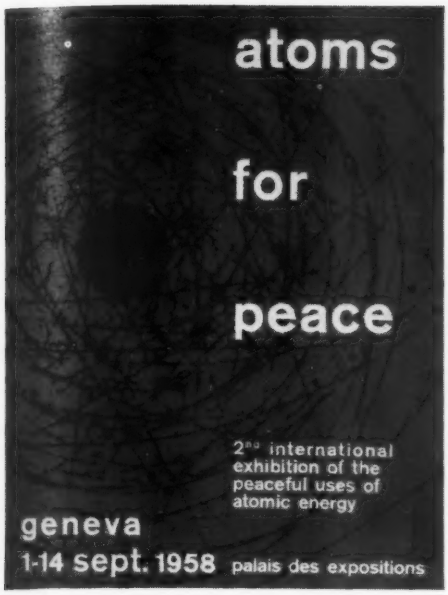
THE NUCLEAR POWER PLANT COMPANY LIMITED

C. A. PARSONS AND COMPANY LIMITED · A. REYROLLE AND COMPANY LIMITED
HEAD WRIGHTSON AND COMPANY LIMITED · SIR ROBERT McALPINE AND SONS LIMITED
WHESSOE LIMITED · STRACHAN AND HENSHAW LIMITED
ALEX FINDLAY AND COMPANY LIMITED · CLARKE CHAPMAN AND COMPANY LIMITED

BOOTHS HALL · KNUTSFORD · CHESHIRE

NPPC


REMOTE HANDLING EQUIPMENT
FOR RADIOACTIVE AND TOXIC MATERIALS
SAVAGE AND PARSONS LIMITED



In addition to the scientific exhibition at the Palais des Nations in connexion with the 2nd UN Conference on the Peaceful Uses of Atomic Energy, a commercial show will be staged in Geneva at the same time.

Preview and guide to the exhibition

With a total of about 300 stands, the 1958 Atoms for Peace *will undoubtedly be the biggest and most comprehensive purely nuclear exhibition ever staged. Many of the exhibits will be on view for the first time anywhere and a tour should give a very good idea of state of nuclear development in the various countries, although it should be borne in mind that the Soviet bloc—apart from a single Hungarian stand—is completely unrepresented.*

The atomic Big Three—America, Britain and France, represented by their national development agencies as well as by their leading private firms—naturally occupy the great majority of the floor space and in fact the French Commissariat à l'Energie Atomique has the largest single stand in the show. These three countries now offer everything from a complete reactor power station to the smallest item of laboratory equipment. A feature of the exhibition however will be the rapid progress now being made by the Euratom countries in the field of instrumentation and, in the case of Germany, nuclear metallurgy.

The exhibition is held at the Palais des Expositions and will be open from 10 a.m. to 7 p.m. every day of the week between Sep 1-14 inc. A frequent bus service will run throughout the day from the Palais des Nations where the UN Conference and Exhibition are being held.

BRITAIN

Atomic Power Constructions (101)

Formed in December 1956 to build complete gas-cooled graphite-moderated nuclear power station, APC comprises: Crompton Parkinson, Elliott Bros, Fairey Aviation, International Combustion, Nuclear Civil Constructors and Richardsons Westgarth. The stand shows some of APC's research and design facilities and a model of a 500 MW power station which could be supplied to the British Central Electricity Generating Board.

Individual exhibits include: a self-regulating alternator with *Magnicon* exciter (Crompton Parkinson); aluminium fabrications for atomic energy, fuel cans for Calder Hall and Windscale, nuclear magnetic resonance spectrometer (Fairey); parts and a model of a heat exchanger (International Combustion); model of a turboalternator set specially designed for nuclear stations (Richardsons Westgarth).

Nuclear Power Plant Co (102)

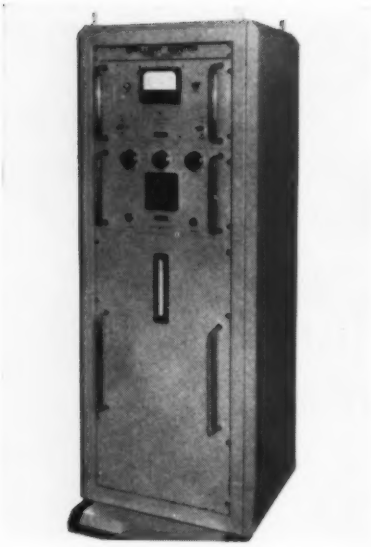
Complete model of a 400 MW nuclear power station with one reactor animated, fully equipped turbine house, switchgear, c.w. pumphouse etc. Model of 100 MW turboalternator specially designed for nuclear stations (C. A. Parsons). Model of a conventional power station (Clarke Chapman). Two models of switchgear equipment (Reyrolle), model of induced-draught cooling tower and a Bradwell boiler (Head Wrightson). Animated display of fuel element grab (Strachan and Henshaw), welds in pressure vessels (Whessoe), structural steelwork (Alex Findlay). Progress at Bradwell power station and at new station in Italy building in cooperation with AGIP Nucleare. Nuclear - propelled ship model in collaboration with Swan, Hunter & Wigham Richardson. Bradwell film.

AEI-John Thompson Nuclear Energy Co (103)

Four models showing: Berkeley 275 MW power station now under construction; MERLIN research reactor two of which are nearly completed in the UK and a third on order for Germany; a typical 150 MW single reactor power station offered for export; SCEPTRE III, AEI's thermonuclear apparatus. Contributions of constituent companies include; welding techniques used at Berkeley and manufacture of the Dounreay Fast Reactor by John Thompson; Calder Hall and Chapelcross control systems, design and construction of ZETA and the 82·5 MW Berkeley turboalternator by Metropolitan-Vickers; Berkeley control system and gas blowers by British Thomson-Houston. Sunvic Ltd and

HIGHLIGHTS

- ★ **Italian power station**
  NPPC
- ★ **Magnetic storage pulse analyser**
  Sunvic
- ★ **Bradwell control cubicle**
  General Radiological
- ★ **100-channel kicksorter**
  Mullard
- ★ **Reactor graphic panel**
  Elliott
- ★ **Rod speed recorder**
  Cambridge
- ★ **Fast scaler**
  Dynatron
- ★ **Microscope photometer**
  Evans



Effluent monitor (106)

Checking effectiveness of DIDO shield with ion chamber and Avo amplifier (104)

Isotope Developments are described below.

Isotope Developments (103)
Portable scintallation counter to Harwell design with sodium iodide detector and transistor circuit to give high sensitivity in four ranges—for car or air survey. Gamma radiation alarm. Scaler with automatic pre-set count and timing—includes 4-range ratemeter Gamma switch for level control. Portable level detector for checking contents of gas bottles, fire extinguishers etc.

Sunvic Controls (103)
Brand-new pulse height analyser (Mk III) incorporates ferrite core storage matrix and is lagely transistorized: totals can be displayed as analogue, a C.R.T. read in decimal form on dekatron tubes, or printed out. A magnetic memory storage drum for the Berkeley burst fuel cartridge computer with a capacity of 500,000 binary digits: each drum will memorize previous 48 counts from each of more than 400 channel groups. Also instruments for reactor power level and control applications.

Avo (104)
A light, portable and self-calibrating monitor measuring alpha, beta and gamma radiation on a 5 in. log scale calibrated 1 mr/h to 5 r/h. A battery-operated monitor with remote ion chamber for use close to high-level sources of beta and gamma radiation. Magnetic memory scaling unit with new magnetic count indicator—power consumption is only 3 mW at 1000 a sec.

EMI Electronics (105)
Hand and clothing monitor detects both alpha and beta contamination on hands simultaneously—gives count in five seconds which is important when large numbers of personnel have to be monitored. General purpose wide-band oscilloscope is specially designed for North American and world market. Photomultipliers for scintillation detection.

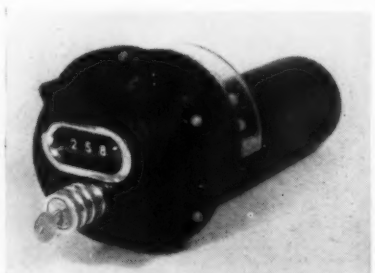
Plessey Nucleonics (106)
Latest developments in reactor control equipment and instrumentation with emphasis on BSD installations for both gas- and water-cooled types. Flux scanning system for gas-cooled reactors using small ion chamber lowered through the core, readings being recorded on a chart. Gamma survey meter calibrated over 3 decades to 500 r/h.

Negretti and Zambra (107)
Pressure amplifiers for remote indication in nuclear plants of small fluctuations—enables recording and control of several parts of plants to be concentrated at a point. Gas measuring probe using diaphragm capsule for determination of gap width.

General Radiological (108)
A complete Bradwell reactor control cubicle fully instrumented by GR. Also, neutron counter withdrawal mechanism used during reactor start-up, neutron-sensitive ion chambers, foil counting equipment for flux scanning, annular ion chambers for flux plotting, neutron monitors, alpha/beta/gamma monitors, transistorized scalers, lead castles, ratemeters precision timers, E.H.T. units, battery H.T. units, control potentiometers and a complete range of isotope handling tools.

R. A. Stephen & Co (109)
Pocket quartz-fibre personnel dosimeters for doses up to 500 roentgens. Dosimeter charging units.

Solartron Electronics Group (110)
Components of the Solartron reactor



Control potmeter for reactor shutdown (108)

Memory drum for BSD system (103)

simulator including computer amplifier mounting unit, d.c. amplifiers and heater units. A wide range of Solartron oscilloscopes. Also on this stand are products of Etelco (Ericsson's)—geiger tubes, dekatron counter, personal alpha/beta/gamma monitor, field ratemeters. Counting equipment used at Harwell and components used in the LIDO reactor. Pulse generators used as test equipment.

Mullard Equipment (111)

A new 100-channel pulse spectrometer or kicksorter, using magnetic memory and transistorized units. Latest reactor safety system based on fail-safe principles. Using transistorized logic circuits, it is claimed to have overall reliability, low power consumption and take up very little space.

Pye Instrument Group (112)

Includes Pye Atomics Division, Labgear Ltd, W. G. Pye & Co and Unicam. Pye Atomics show: two master/slave manipulators in conjunction with stereoscopic and normal television cameras controlled by foot pedals. Also a CO_2-cooled camera for reactors. Labgear will have its complete range of unitized nuclear counting instruments including a new four-pie counter for alpha and beta activity in gas samples and the latest version of the gamma monitor which now has alarm circuits adjustable over six decade. Unicam's part will include a range of spectrophotometers for analysis of radioactive materials under remote control. Among W. G. Pye's exhibits is a new argon chromatograph.

Elliott Bros (113)

A complete reactor graphic panel with Elliott 54pt scanning recorder for burst slug detection. *Dynamaster* recorders for rod position, gas flow rates and integration, heat output. Swartwout recorders operating from pressure and differential pressure transmitters at various parts of the gas circuit. Panellit annunciators indicating fault and alarm conditions. Working demonstrations on the Elliott reactor simulator ND 181 designed for instructional purposes. Individual reactor instruments on view will include: micro-microammeter for measurement of ion chamber currents with six switched linear ranges between 10^{-6} and 10^{-11} amps; log amplifier for health ion chamber currents in the range 10^{-7} to 10^{-12} amp; power deviation meter; multi-range linear d.c. amplifier for power level on five switched ranges from 100 pc to ·01 pc of max. power. Also in this stand will be the Gordon thermally sealed butterfly valve for gas circuits.

HIGHLIGHTS

- ★ **Flexible glove boxes**
  Townson & Mercer
- ★ **Needle counters**
  20th Century
- ★ **Rod Actuators**
  Sperry
- ★ **Irradiation unit**
  Nuclear Engineering
- ★ **Hinkley Point details**
  English Electric
- ★ **Full-size Hunterston model**
  GEC
- ★ **Reactor control systems**
  Hobson

Chance-Pilkington Optical Works (114)

Specimens of radiation shielding glass in densities of 6·1, 4·3 and 2·5 g/cc. The 4·3 glass will be shown in both stabilized and unstabilized form—it is now available in blocks up to 4 ft 6 in. square and 10 in. thick.

Cambridge Instrument Co (115)

Rod-speed recorder for testing emergency shut-down system—chart re-records complete dynamics of fall—test cycle is completely automatic. Carbon dioxide purity indicator gives alarm if gas falls below pre-set level. Latest model dissolved oxygen analyser specifically for nuclear power station employs novel electrochemical method of detection, specific for oxygen — glass components are reduced to a minimum. Entirely new 'Centre-line' controller for simple on/off or proportional working—embodies novel optical display system with effective scale length of 20 in.

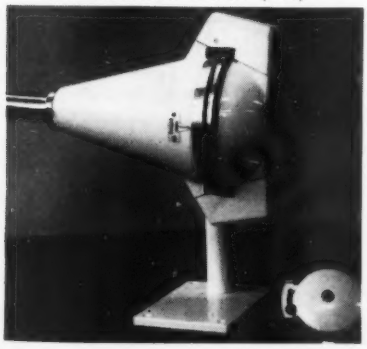
Ekco Electronics (116)

Working demonstrations of nucleonics in industry, medicine and research. Control panel for PLUTO and DMTR including new transistorized units. New beta-excited X-ray thickness gauge (Sr-90) for metals up to 10 mm thick. Transistorized, printed-circuit gamma backscatter gauge ratemeter and scintillation counter.

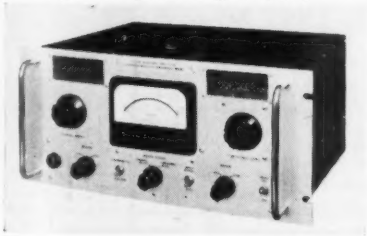
Dynatron Radio (116)

Scanning pulse amplitude analysers selecting only pulses between two set levels. Transistorized battery-operated five-decade portable scaler for field use. Fast scaler counting to 2,500

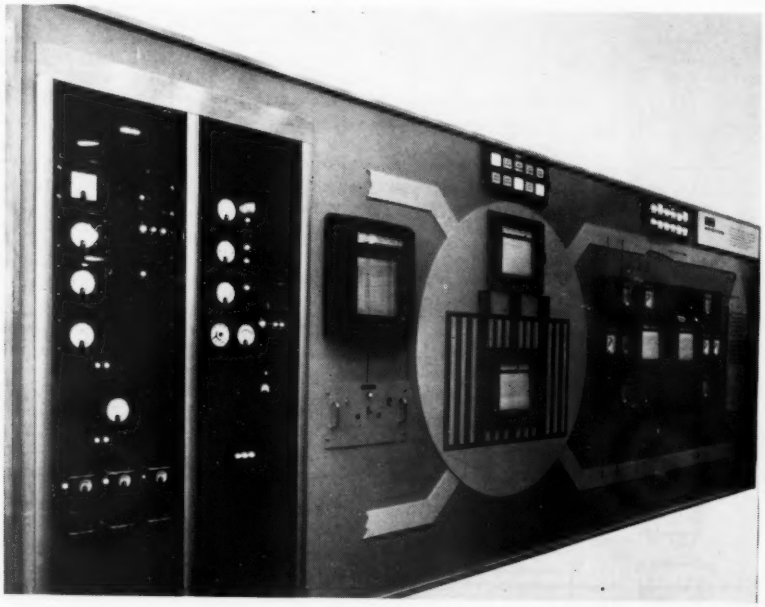
New scintillation counter (116)



Dynatron pulse analyser (116)



Power reactor graphic display panel (113)



pulses per sec. of amplitude greater than a preset value. Three-channel coincidence unit with facilities for varying amplitude discrimination, paralysis time and delay time.

Dawe Instruments (117)
New pulse generator for checking linear amplifiers, scaling units and setting discriminator bias levels. Ultrasonic cleaning equipment for radioactive decontamination.

Cossor Instruments (117)
Several double-beam oscillographs—some with a new 4 in. p.d.a. tube. Oscillograph cameras and drive units. Transistor tester. Power units. Millimicrosecond pulse generator. Millimicrosecond pulse test set for investigating passive and active networks.

Electronic Instruments (117)
Vibrating condenser electrometers for measuring extremely small d.c. currents down to 10^{-16} amps). They use the new *Vibron* electrometer valve. *Vibron* gamma-ray electrometer for measuring concentration of uranium ore in a slurry as it flows in a pipe.

Evans Electroselenium (117)
First view of reflexion microscope photometer for indentification of mineral ores—works by varying reflectance values. Blood-cell counter, widely used in health physics.

Nash and Thompson (117)
Wide range of organic scintillators in crystal, plastic and liquid form.

Stanton Instruments (117)
Range of precision balances including free-swinging and aperiodic models, single pan types and thermo-recording systems.

Taylor, Taylor and Hobson (117)
Quartz fibre electrostatic pocket dosimeters (*Kershaw*) covering the range 0·5 to 1,000 roentgens.

Townson and Mercer (117)
Rigid glove boxes to UKAEA requirements lined and sealed with Melamine resin. Flexible glove boxes with integral gloves—cheap and expendable for low active use. Complete range of Harwell tongs with interchangeable heads.

20th Century Electronics (118)
New geiger counters built into needles which can be inserted in the human body—smallest is 2 mm dia. Also standard enriched BF_3 proportional counters, fission chambers, reactor ion chambers and fast neutron counters. Stable isotopes—B-10 and C-13—produced in low temperature distillation plant.

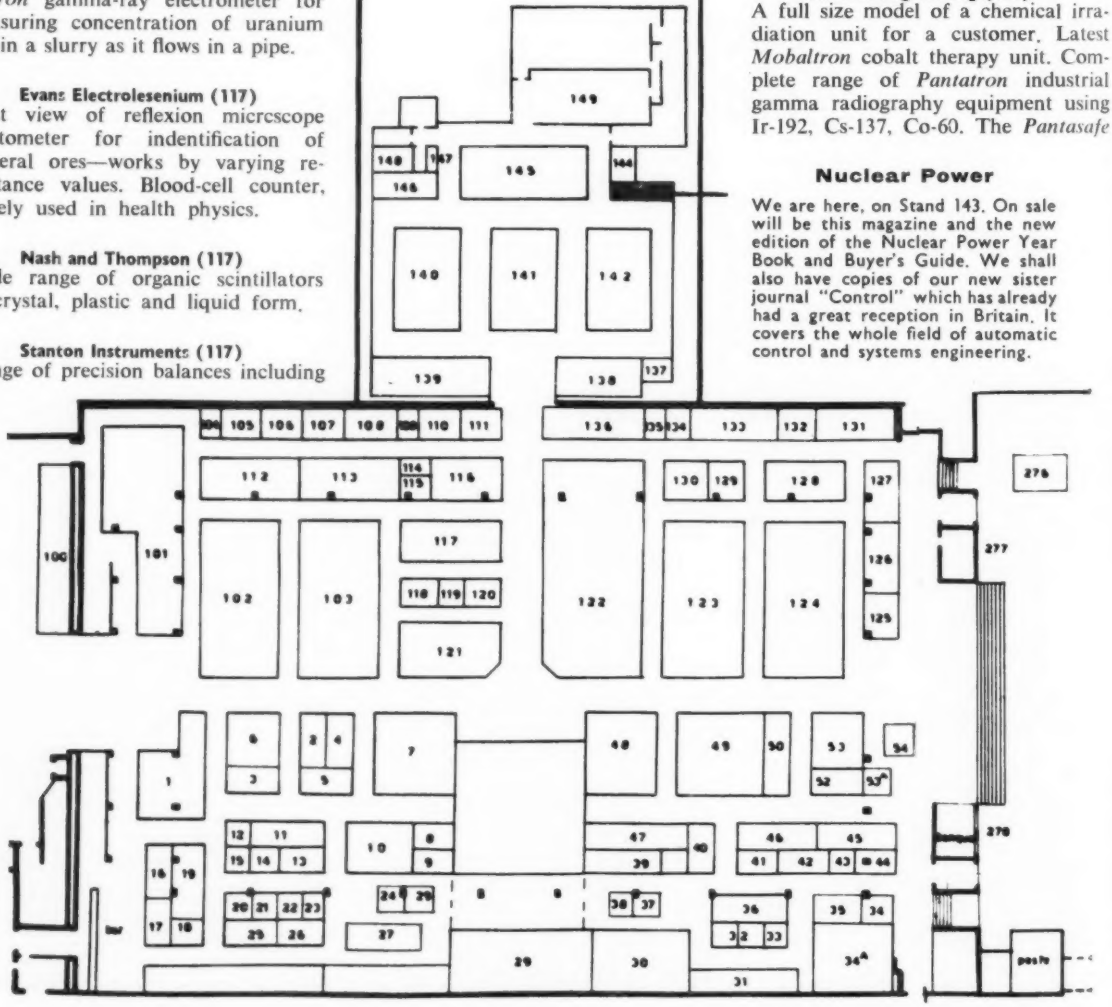
The Sperry Gyroscope Co (119)
Reactor control rod winding mechanism incorporating features for safety, reliability and ease of operation and maintenance. Servo-driven control rod position indicator gives general position of rod, absolute position to 0·1 mm and 'tell-tale' indication of speed and movement direction. An example of d.c. vernier or stepping motors, a range of precision synchros and specialized sensing devices.

Fleming Radio (120)
Air pollution recorder for monitoring radioactivity or concentration in given area. Effluent monitor—transistorized with encapsulated g.m. tube—for checking liquids. Personal radiation monitor with audible warning. Five-decade log ratemeter—range 5 to 500,000 c/s for reactor trip circuit control.

Nuclear Engineering (121)
A full size model of a chemical irradiation unit for a customer. Latest *Mobaltron* cobalt therapy unit. Complete range of *Pantatron* industrial gamma radiography equipment using Ir-192, Cs-137, Co-60. The *Pantasafe*

Nuclear Power

We are here, on Stand 143. On sale will be this magazine and the new edition of the Nuclear Power Year Book and Buyer's Guide. We shall also have copies of our new sister journal "Control" which has already had a great reception in Britain. It covers the whole field of automatic control and systems engineering.



isotope storage with 40 containers for needles, wires, applicators, liquids etc.

UK Atomic Energy Authority (122)

Practical aspects of nuclear reactors, instruments and materials available for sale with an emphasis on the fuel element service which can support the export of reactors, together with developments in isotope production and sales service. Backed by films with multilingual soundtracks these subjects are covered by actual exhibits, animated diagrams, models and photographs.

English Electric, Babcock & Wilcox, Taylor Woodrow Atomic Power Group (123)

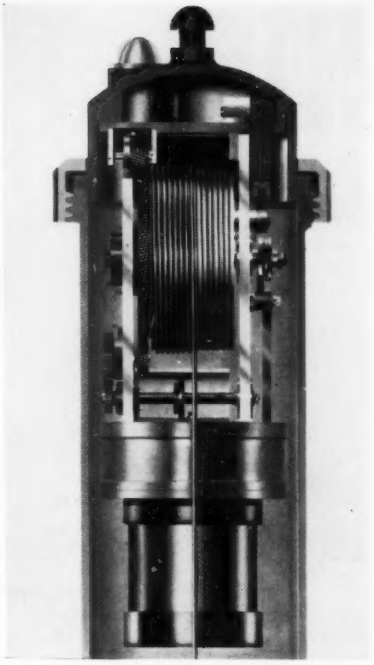
Models of Hinkley Point: the whole station covering 7 ft by 7 ft; the reactor showing details of the core, fuelling arrangements, cooling and steam raising; a 6-ft high model of a Hinkley boiler showing how steam output has been boosted using greatly increased heat exchange surface per unit volume of shell. Display panels show further details of Hinkley station and include core support structure internal insulation in the upper part of the pressure vessel. Other panels show aspects of the group's research and development activities, including examples of fuel cans showing progressive improvement of finning, specimens showing effect of hot carbon dioxide on steel, zirconium and titanium, fuel element supports in zirconium, samples of uranium thermally cycled through the alpha-beta transition, effect of internal pressure on fuel can end cap welds, a special control rod shock absorber, specimens of welding techniques. Other display panels show artists' impressions of single reactor stations in the range 150-200 MW.

General Electric Co and Simon-Carves (124)

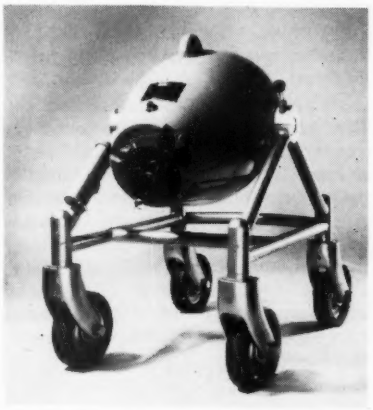
Visitors will enter full size model of Hunterston reactor vessel through gas outlet duct. Inside will be seen the core with reflector, boron sandwich shield, double-shell pressure vessel, fuel elements, control rods and burst slug piping system. Other exhibits include working display of impermeable graphite developed at GEC research labs. Illuminated schematic diagram of the Winfrith Heath high temperature gas-cooled reactor zero-energy experiment GEC are building for the AEA. Animated diagram showing Hunterston burst slug system in which gas samples are automatically taken every 40 minutes from 3,288 channels. A sectioned model of

HIGHLIGHTS

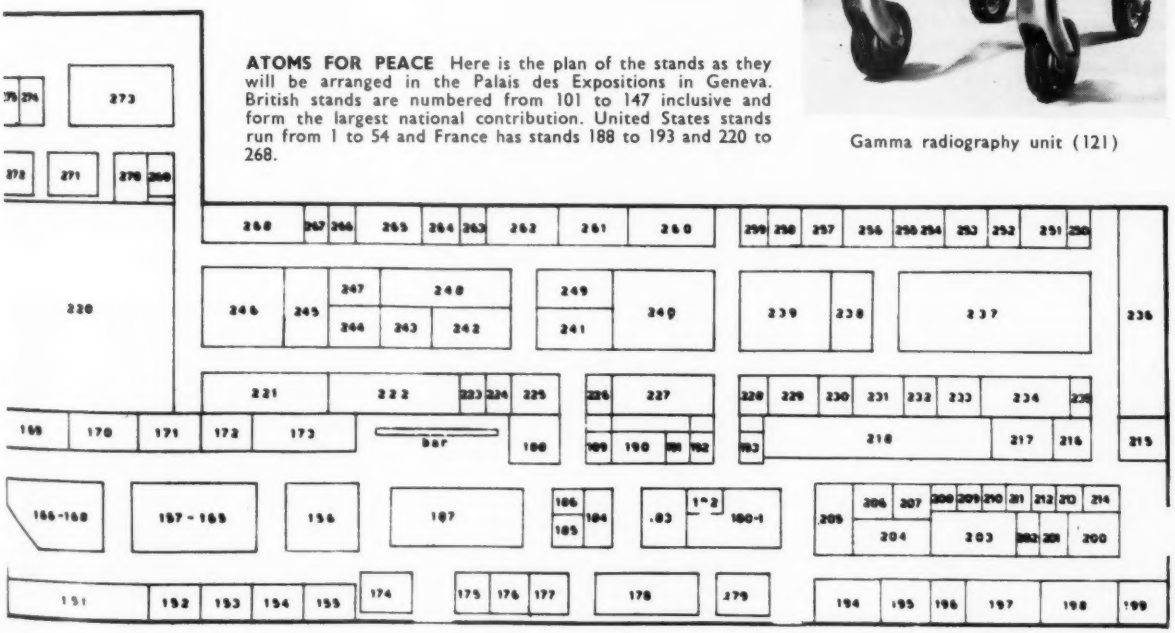
- ★ **Ceramic elements**
  de Havilland
- ★ **Isotope tracing system**
  Nuclear Enterprise
- ★ **90-pt scanning recorder**
  Kent
- ★ **Remote swarf collector**
  Vokes
- ★ **Integral fin tubes**
  ICI
- ★ **Jason research reactor**
  Hawker Siddeley
- ★ **Oval finned tubes**
  TI Nuclear



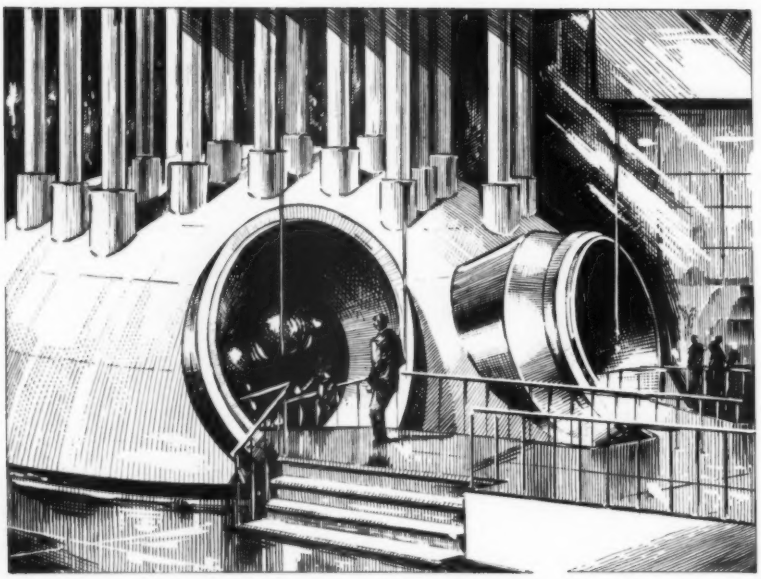
Reactor control rod actuator (119)



Gamma radiography unit (121)



ATOMS FOR PEACE Here is the plan of the stands as they will be arranged in the Palais des Expositions in Geneva. British stands are numbered from 101 to 147 inclusive and form the largest national contribution. United States stands run from 1 to 54 and France has stands 188 to 193 and 220 to 268.



Full-size model of part of Hunterston reactor pressure vessel (124)

a Simon-Carves Hunterston boiler raising 143,100 lb/h. Working demonstration of the new heavy duty power-operated manipulator which has no mechanical connexion between operating console and arm, GEC sintered tungsten-based heavy alloy for shielding.

Ferranti (125)

The *Mercury* high speed electronic computer. Three of these are already in use for nuclear work—Harwell, Paris, Oslo and the fourth is being installed at CERN. A system has been set up for exchanging information among users. Firm says *Mercury* can solve problems 50 times faster than any computer made in Western Europe. It costs £100,000.

Aiton & Co (126)

Full size heating unit and ebullition chamber for *Alkacide* plant and evaporator for purifying sea or estuary water, for nuclear power stations. Demonstration of Mark 2 *Uniload* constant load pipe support. Two large bellows expansion joints — one in chrome molybdenum the other in stainless steel. Samples of special pipework.

De Havilland Nuclear Power Group (127)

The firm are building a high temperature gas loop for PLUTO reactor at Harwell. It will test a new type of ceramic fuel element working at 800°C. A model and diagrams illustrate this. Other exhibits are: a self-acting gas bearing, a small high speed gas circulator using these bearings and components for use in control and shut-off valves in radioactive gas circuits.

Rolls Royce (128)

Model and details of NEPTUNE reactor built at Harwell to develop propulsion PWR. Fine control gearbox designed for Harwell LIDO. Working analogue computer for reactor control systems. Special shielding.

H. M. Hobson (130)

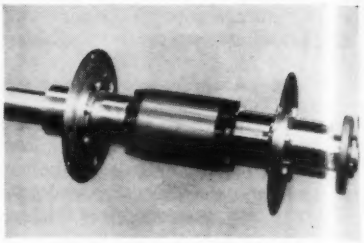
Reactor control systems with slave and master gearboxes of the type supplied for DIDO and PLUTO type of research reactor. Hobson-CRL master-slave manipulator. High-density barytes shielding bricks.

Mitchell Engineering (131)

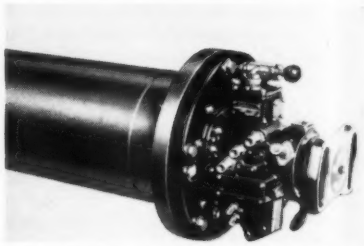
Scale model of 17·5 MW closed-cycle boiling water reactors designed in association with AMF Atomics and General Nuclear Engineering of USA. Core of actual project is 5 ft dia and 5 ft high, comprised of 164 3 pc enriched UO_2 fuel assemblies. Steam conditions are: 900 psi, 535°F. Illuminated flow diagram will show this reactor and also 70 MW model.

Nuclear Enterprises (132)

First time in public—an industrial isotope tracing system using new multi-channel scintillation spectrometer. It enables one operator to observe readings from four remote detector heads situated at as far as 300 ft from the central point. Using short-lived or highly diluted isotopes, flow patterns can be studied and optimum blending times simply obtained. Tritium counting installation involving new non-overloading amplifier and single channel differential pulse height selector. Wide range of plastic, liquid and crystal scintillators, including gadolinium- and samarium-loaded liquids.

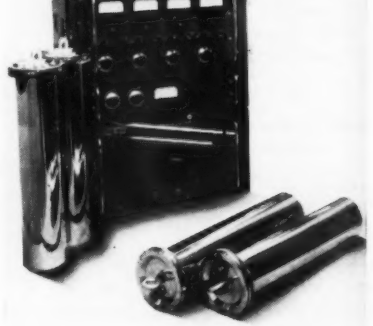


Gas-bearing circulator (127)



Honeycomb isotope production unit (130)

Model of 17·5 MW BWR (131)



Multi-channel scintillation spectrometer (132)

Fuel cans in Al and Mg alloys (140)

Saunders-Roe (132)

Model of a prototype industrial irradiation plant.

Rio Tinto (133)

A specimen of uranium concentrate containing over 80 pc U_3O_8 in the form of sodium uranate. Rio Tinto's annual production of this yellow cake from their mines in Australia and Canada is equivalent to 5,500 tons of metal a year.

Hayward Tyler (134)

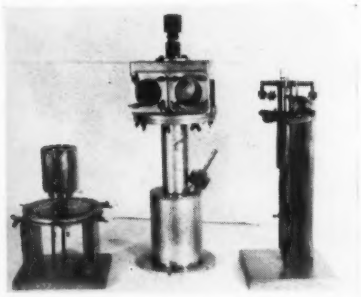
A sectioned model of the type of glandless motor pump used for boiler circulation in British nuclear power stations.

George Kent (135)

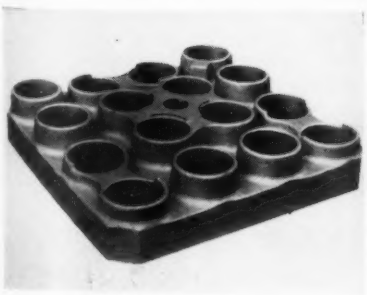
New version of *Multelec III* high-speed electronic strip-chart recorder scanning 90 individual points with identification of each reading. Kent-Barton non-mercurial meter for flow, level and s.g.—for wet gas or corrosive fluids. Manually-set on/off electronic controller for shut-down amplifiers or alarms. The new Kent synchronous converter. Full range of *Dall* tubes, orifices and pilot tubes.

Vokes Group (136)

A special glove-box filter and fume removal unit. Vokes' new mobile swarf collector used in remote machining operations. *Genspring* constant support hanger for piping and ducting in nuclear power stations. Range of oil filters and cleaners by Stream-Line Filters.



Creep test machine for liquid metals (141)



Hunterston charge pan (144)

Mond Nickel (138)

Will feature their technical information service including over 60 different publications in various languages.

Shell Petroleum (139)

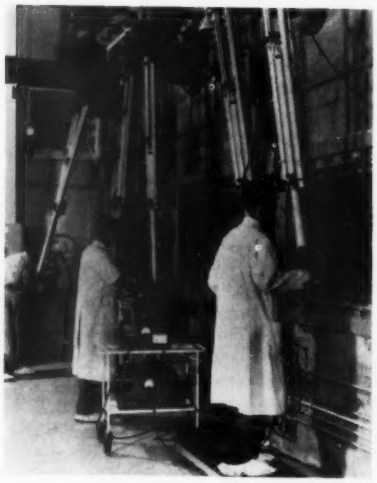
Model showing radiation laboratory facilities by which a range of special atomic power lubricants were developed and introduced in May 1957. Model of Bradwell, where Shell APL will be used. Research into conventional lubricants using isotopue techniques.

Imperial Chemical Industries (140)

Zirconium in all wrought forms—fuel element support brackets for Berkeley power station. Fuel cans in aluminium and *Magnox* in many different forms. Plate type elements for British research reactors. Samples of beryllium, vanadium and niobium. *Integron* heat exchanger tubing for power stations. A tube bundle for connecting the burst slug detection gear to the inside of a reactor with 221 stainless steel tubes brazed into a plate 14½ in. dia. An Amal flow pack for the UKAEA available in zirconium, titanium etc.

Hawker Siddeley John Brown Nuclear Construction (141)

A one-tenth scale model of the JASON research and training reactor based on Argonne's ARGONAUT. Normal power is 1 kW (max 10 kW) with a max. flux of $1{\cdot}5 \times 10^{11}$. Simple and inherently safe it is suitable for universities and colleges. Analogue computer by Hawker Siddeley Nuclear Power Co and A. V. Roe for reactor kinetic problems including evaluation of effects of eleven delayed neutron groups present in heavy water reactor systems. Totally enclosed and electrically monitored area type flow meter, sections of fuel element cans and control rod mechanisms.



Stabilized optical glass (114)

T.I. Nuclear Engineering (142)

This stand comprises products of seven companies in the Tube Investment group. Various methods of fin attachment for extended surface heat exchanger tubing is shown—spiral *Integral* fins (Accles & Pollock), spiral fins resistance welded to tube wall (Tube Products), spiral fins shrunk onto tube wall (Howell & Co). Samples of oval section tubes with external finning designed to minimize gas pressure drop. For gas to gas heat transfer, tubes finned helically on the outside and with integral longitudinal fins on the inside (Tubes Ltd). Selection of fuel cans in pure aluminium and magnox alloy (Accles & Pollock). Impact extruded cans for British power stations with longitudinal and spiral fins. Tubes in: zirconium (Accles & Pollock, Chesterfield Tube and Tubes), including flexible hose; hot extruded beryllium (Chesterfield); round and ribbed niobium (Accles & Pollock); vanadium (Accles & Pollock).

A variety of reactor details by the various companies, including: fuel element supports, charging tubes, control rod with 3 pc boron steel (Chesterfield). Thermocouple guide tubes for Dounreay fast breeder (Talbot Stead), electromagnetic pump tube, seamless with special magnetic properties (Chesterfield).

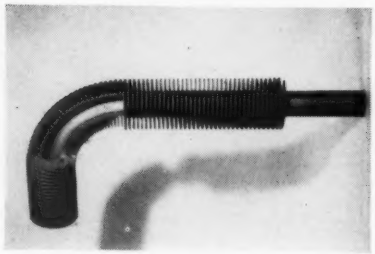
From Crane Packing will be shown a 7 in. dia seal for hot CO_2 circulators. Also a number of gland packings for gases such as UHF_6 and a bellows pump in PTFE for corrosive liquids.

The A.P.V. Co (144)

Samples of aluminium welding for DIDO, MERLIN and NEPTUNE reactor tanks. A reactor charge pan for Hunterston power station in BS 592B steel. Lantern and plug castings for Bradwell. Castings in corrosion—and heat-resisting materials for other nuclear energy projects. *Paralloy* cast stainless and alloy steel welding pipe fittings.

Vickers Nuclear Engineering (145)

The company is building the pressurized water reactor plant for British



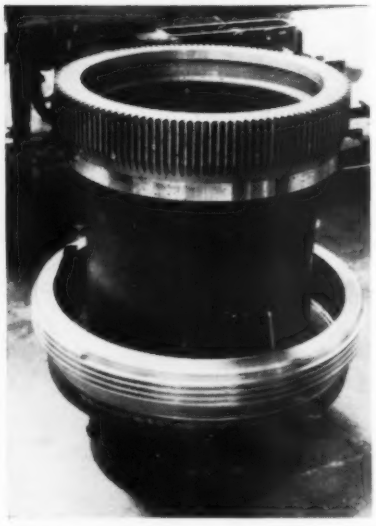
Helical wound welded fins (142)

nuclear power submarine *Dreadnought* but do not feature this as it would be out of place in this exhibition. They are however showing models of a pressurized water reactor in a large tanker and an advanced gas cooled reactor in a supertanker. Also a model of Harwell's LIDO reactor which they built. Group includes Vickers, Foster Wheeler and Rolls-Royce.

Savage & Parsons (146)
Power-operated manipulators for under water remote handling of Calder Hall fuel elements. A complete basketful of 24 elements can be transferred to skips in 30 minutes. New multi-point thermocouple recorder for gas-cooled reactors, giving permanent printed record from 500 points, including time of reading. Maximum rate of printing is 100 readings a minute.

Newman, Hender & Co (147)
A selection of forged steel valves specially designed for nuclear power applications includes: globe and gate valves, needle-type bellows-sealed valves and parallel-slide valves with seal-welded flanges.

Geartight Unions (154)
Shown on the stand of BOA Metallschlauchfabrik in the Swiss section is a closure unit for the control rod standpipes at Hunterston power station. Over 400 of these will be supplied by Geartight. The threads are 3-start, ½ in pitch, modified acme and the unit takes about 1½ turns to seal. The firm are supplying units working on the same principle for Berkeley.



Hunterston stand pipe (154)

UNITED STATES

Columbia-National (2)
Nuclear- and commercial-grade zirconium metal and alloys produced at C-N's Pensacola plant—claimed to be the largest fully-integrated zirconium works in the world.

High Voltage (6)
The 30 ft high accelerating column of a 6 MeV Van de Graaff built for the University of Strasbourg. Model of the 10 MeV tandem Van de Graaff.

General Atomic (7)
Details of the TRIGA research and training reactor, an example of which will be in operation at the scientific exhibition at the Palais des Nations.

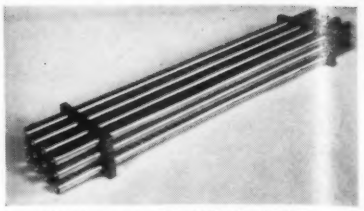
HIGHLIGHTS

- ★ **Zirconium products**
  Columbia-National,
  Carborundum etc
- ★ **Enriched uranium**
  Mallinckrodt,
  Union Carbide
- ★ **Automatic scintillation spectrometers**
  Packard, Baird
- ★ **Fermi fast reactor**
  PRDC
- ★ **Actual research reactors**
  Atomics International,
  Aerojet-General

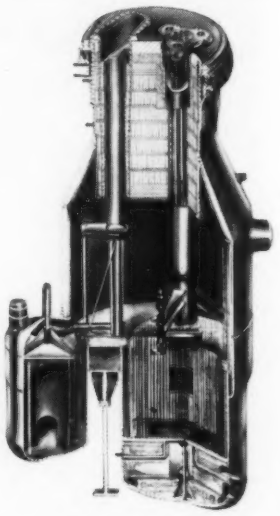
Allis-Chalmers (10)
Panel showing reactor operation. Model of a 60 MW plant being built by A-C in the United States. Some of the work being done in cooperation with the Radio Corporation of America for the Princeton C stellerator thermonuclear apparatus. Uranium mining equipment.

M & C Nuclear Inc. (14)
Fabrication of the following types of fuel elements and components: uranium/aluminium elements for training research and test reactors; uranium-zirconium plate type and UO_2 stainless steel plate type fuel elements for power reactors; UO_2 pellets in stainless steel tubular fuel elements; uranium wire; uranium or thorium foil, strip or unique configurations for experimental use; and other products.

Edgerton, Germeshausen & Grier, Inc. (15)
Precision instrumentation in the submillimicrosecond range, hydrogen thyratrons and other advanced electron tubes, high speed photography. For the AEC the company has designed, installed, operated and maintained, telemetering and other electronic networks covering hundreds of square miles.



SS element with UO_2 fuel (14)



Fermi fast reactor (39)

Automatic gamma spectrometer (32)

Automatic scintillation spectrometer (40)

G·A·M·E*

This is one of the magnetic memory drums used in G.A.M.E, the Sunvic data handling computer for analysing information from scintillation counters used to detect reactor fuel cartridge leaks.

The drum can memorise the previous 48 counts from each of 400-600 channel groups so that the previous 24-hours readings are always available. It also stores individual channel group reference levels and differential limits; each reading can thus be assessed arithmetically and warning given of *significant* variations in gas activity. The computer has completely self-checking circuitry with built-in fault finding equipment.

A memory drum and a new prototype pulse height analyser are among the Sunvic equipment shown on Stand No. 103 at the Geneva "Atoms for Peace" Exhibition.

The covers of the memory drum have been removed and one bank of recording heads withdrawn. It revolves at approximately 150 r.p.m. and has a capacity of roughly 500,000 binary digits.

* **Gas Activity Monitoring Equipment—a patented system developed by Sunvic Controls, which is being supplied for C.E.G.B. use at Berkeley nuclear power station. For further information, please contact:**

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Not only instruments but complete instrumentation

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SC 75

from

Geneva to

At Geneva, in 1955, the first International Conference on Atomic Power offered a new hope of peace to a world sick of war.

The second Atomic Power Conference is now convening at Geneva. At Berkeley, the AEI-John Thompson Company is well ahead with the construction of Britain's first commercial nuclear power station.

Between Geneva and Geneva, peaceful atomic power has become a reality. AEI-John Thompson, now marketing 5 MW research reactors of the 'Merlin' type, is leading the way to important developments for the future.

A·E·I
JOHN THOMPSON

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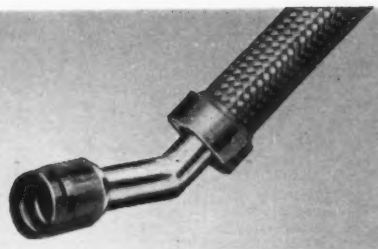
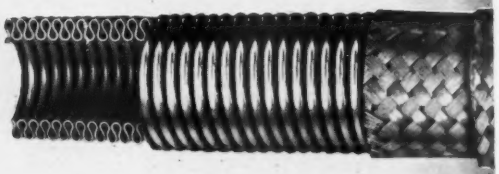
to Geneva

Tick **No 80** on reply card for further details

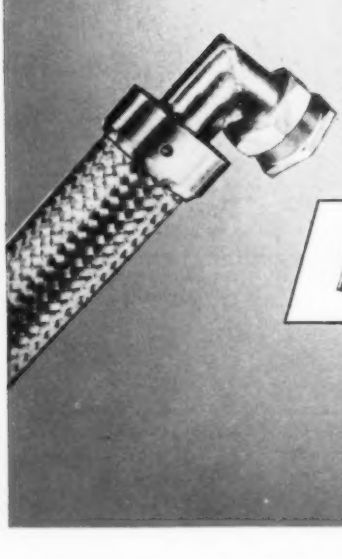


Nucleonics and Plessiflex

Plessiflex is acknowledged to be the best flexible stainless steel hose for most applications—and is particularly outstanding in the field of nucleonics. Produced from solid drawn tubing, Plessiflex is absolutely seamless and immensely strong. As a result Plessiflex may be employed simultaneously as a hoist rope and as a gas or fluid connector with the minimum of extensibility. It is ideal for charging machines, cable conduits, gas ducts, remote pneumatic handling or safety monitoring circuits. High purity aluminium, nickel or zirconium hoses can also be supplied for special applications.



If you have a problem which could be solved by the employment of flexible hose—consult Power Auxiliaries Ltd. Specialists in this field, Power Auxiliaries Ltd., have built up extensive design experience which is readily available to all equipment producers.



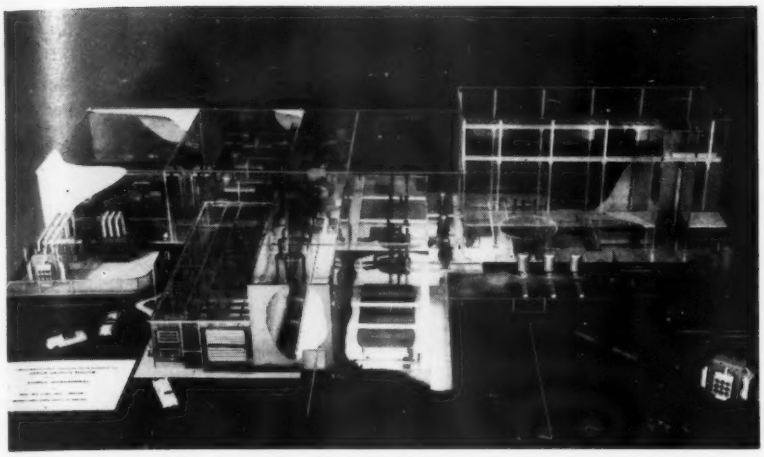
PLESSIFLEX

flexible seamless metallic hose

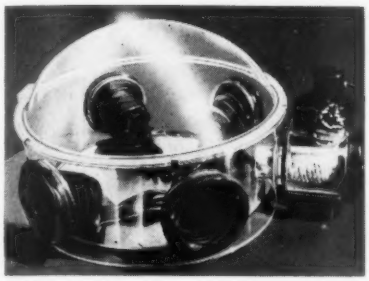
Power Auxiliaries Ltd., Kembrey Street, Swindon, Wilts. Phone: Swindon 5461

One of the Plessey Group of Companies

PAL5



Atomics International 75 MW organic moderated power plant (49)



Circular glove box (43)

Ball Brothers Research Corporation (17)
Gamma ray borehole logger using 1½ in. dia scintillation probe, the subject of a paper at the conference. Fluorimeter for determination of millimicrogram amounts of uranium in ore samples, water etc.

ACF Industries (19)
Details of reactors building for Massachusetts Institute of Technology and the Italian nuclear centre at Ispra (CP5's), Reactor Centrum Nederland, AB Atomenergi (Sweden) and the US Air Force.

Mallinckrodt Chemical Works (20)
Views of the plant at Hematite, Missouri, where enriched uranium hexafluoride from the Oak Ridge diffusion plants is converted into metal and compounds.

Beryllium Corp (22)
Details of the firm's new plant for fabrication of beryllium metal which has just gone into operation at Hazelton, Pa.

Edison Electric Institute (25)
Details of 27 nuclear power projects being carried out in the US by 123 power companies whose announced total expenditure is over $M500.

The Carborundum Co (26)
Zirconium fabrications such as heat exchangers, reaction tanks, pumps, valves etc. Also zirconium in all wrought forms.

Aerojet-General Nucleonics (28)
Details of the AGN low power research and training reactors. A complete reactor will be seen on the AEC stand.

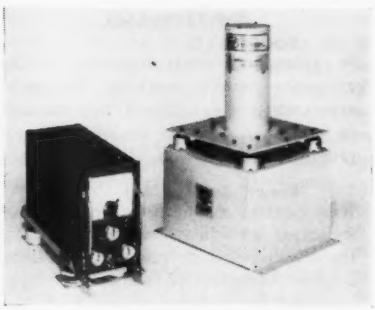
US Atomic Energy Commission (29, 54)
Organized by Atomic Industrial Forum Inc, the exhibit is designed to show the partnership between the Government and private industry. Focal point is a full-scale model of a 150 MW core. Also two 'live' laboratory reactors—Atomics International's J-77 and the Aerojet-General AGN 201.

Packard Instrument Co (32)
Instruments for liquid and solid sample counting of isotopes. Automatic *Tri-Carb* liquid scintillation spectrometer—a refrigerated double-coincidence liquid type—has two channels of pulse height analysis and two transistorized scalers.

Power Reactor Development Co (36)
This company are building and will operate the Enrico Fermi fast breeder 100 MW power station at Lagoona Beach near Detroit.

Combustion Engineering (39)
Illuminated cutaways of the Enrico Fermi fast breeder and the 60 MW Shippingport PWR, pressure vessels and internals of which were both built at Combustion's Chattanooga plant.

Baird Atomic (40)
Automatic scintillation spectrometer featuring simultaneous logarithmic and linear display. For precision work



Airborne scintillation counter (17)

dynamic counting rate levels can first be established on the log scale, then the appropriate linear range chosen for optimum analysis.

Tobe Deutschmann Corp (42)
Low inductance capacitors supplied to US fusion experiments. Demonstration of a pinched tube effect.

P. M. Lennard Co (43)
Novel hemispherical glove box with internal turntable. Other glove boxes in transparent plastic or stainless steel with airlocks, filter systems and all accessories.

Edlow Lead Co (44)
Full-scale model of a transport cask for irradiated ETR and MTR elements—adaptable to others. Disposal containers for waste materials, lead bricks, isotope containers and other lead items.

Picker International Corp (45)
A cobalt-60 therapy unit capable of handling up to 2000 curies of high specific-activity material.

Alco Products (46)
Alco built the US Army's APPR-1 2 MW pressurized water reactor and now they are building a similar plant with twice the output for a site in Alaska.

AMF Atomics (47)
A control console for a research reactor connected to an actual core plate containing dummy fuel elements and control rods—actual operation will be simulated. Details of 16 AMF research reactors built or building.

Union Carbide International Co (53)
High grade purity nuclear graphite. Various types of reactor-grade uranium materials, niobium, vanadium and tantalum, rare gases. Illustrations of work at Oak Ridge which is operated by Union Carbide, including a large model of DCX—the experimental fusion apparatus.

SWITZERLAND

SODECO (153)

A range of electromagnetic digital counters—mostly working. In nucleonic counting equipment they are used in conjunction with decade tubes to give the higher orders.

Brown, Boveri (156)

Rod control mechanism with position indicator and heavy water pump for the Swiss research reactor at Würenlingen. Samples of welds developed specially for nuclear work.

Aluminium Schweisswerk (164)

An 11-ft high welded aluminium tank for the Swiss heavy water testing reactor at Würenlingen. It will contain 243 fuel rods and 9·6 tons of heavy water.

Oerlikon (168)

Centrifugal blowers for the Belgium centre at Mol. Details of the heavy-water separation process developed with Sulzer.

Trüb, Täuber (171)

Nuclear induction spectrograph for examination of the structure of organic compounds—particularly those containing hydrogen, which has high nuclear magnetic moments.

AUSTRIA

C. Reichert Optical Works (185)

The *Telatron* remote-controlled reflected light microscope for examination of highly radioactive specimens, one of which is already in use at Harwell with another on order.

BELGIUM

Belgonucléaire (182)

This is a consortium of 43 Belgian companies, including such well-known firms as: ACEC, Bell Telephone, Cockerill-Ougrée, Coppee, FN, Hoboken and Haut-Katanga. Belgonucléaire is presently engaged with consulting engineers in designing an 11·5 MW power reactor—BR3—for the Centre d'Etudes de l'Energie Nucléaire at Mol, and other studies.

HOLLAND

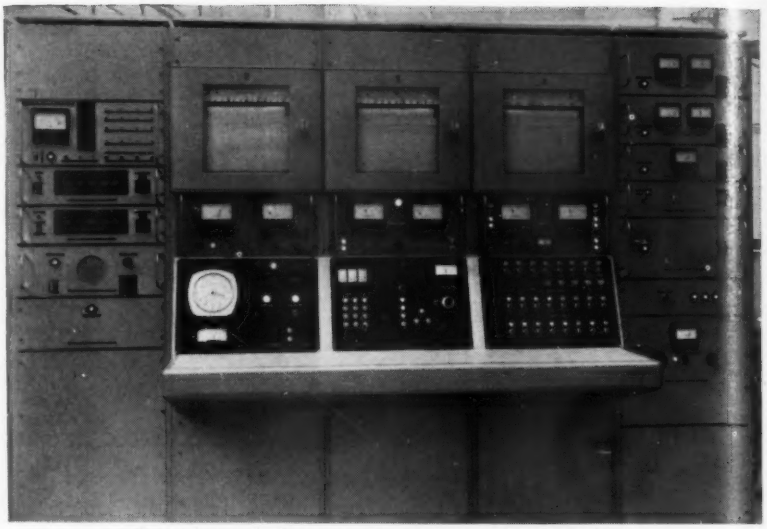
Philips (187)

A replica of the control console built for the AMF pool reactor built originally for last year's Amsterdam exhibition. Transistorized portable contamination monitor with three measuring ranges, pocket quartz-fibre dosimeters, transistorized pocket radiation monitor.

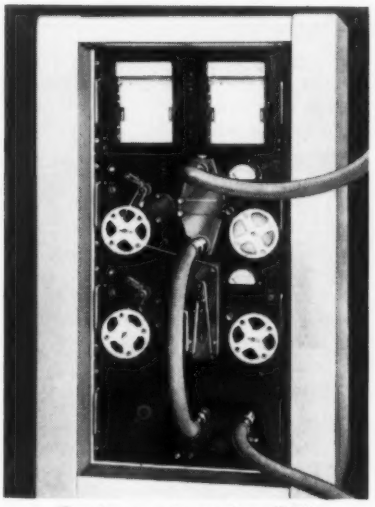
GERMANY

W. C. Heraeus (197)

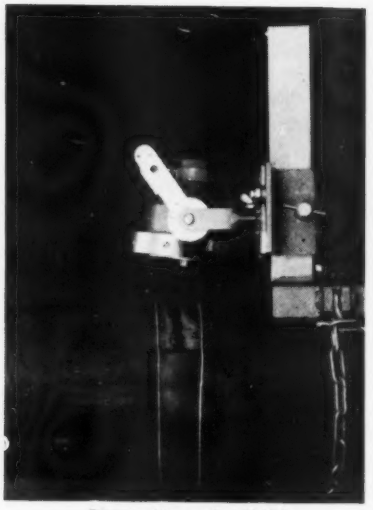
Vacuum-melted zirconium sheet, rod, wire, seamless and welded tubes, heat-exchangers and reactor components. Zirconium-clad tanks. Vacuum metallurgical plants for melting, casting, sintering and heat-treatment.



Control console for swimming pool research reactor (187)



Continuous air monitor (205)



Pipe radiography (217)

Physikalisch-Technische Werkstätten (198)

A pocket transistorized dosimeter giving an audible alarm—weighing only 12 oz. it's powered by a chargeable battery. Fountain pen dosimeters and charging units. Range of clinical dosimeters for radiotherapeutic applications.

Jena Glassworks (200)

Stabilized glass with densities ranging from 2·5 to 6·2—in densities above 5 the highly refractive types have anti-reflective treatment. Bubble chamber windows and lead glass for Cerenkov counters. Stabilized optical glass for instruments subject to radiation.

E. Leybold's Nachfolger (203)

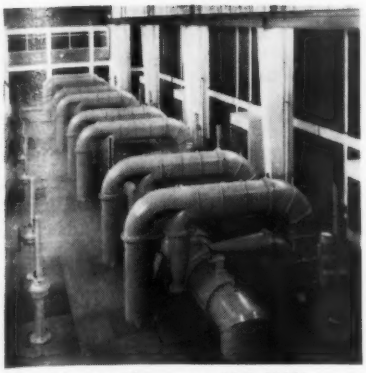
A master-slave manipulator and other remote handling tools, model of a nuclear research laboratory, high vacuum equipment of all kinds including an ultra-high-vacuum packaged pump system.

Interatom (204)

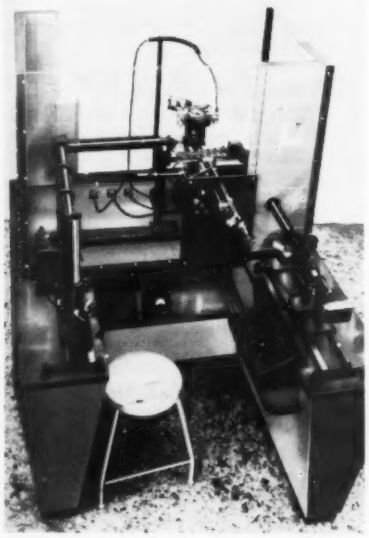
Formed by Demag of Duisburg and North American Aviation, Interatom show two models of Atomics International's organic moderated reactors—the prototype OMRE and a large 100 MW power station concept. Also a model of the 10-watt laboratory reactor L-77—which can be seen working on Atomics International's own stand (49).

Frieske and Hoepner (205)

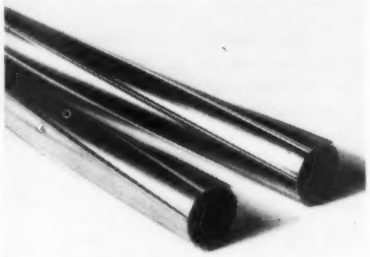
A novel continuous air monitor in which the samples are delayed so that the effects of short-lived natural radioactivity such as radon, thoron and their daughter products can be separated from the longer-lived elements.



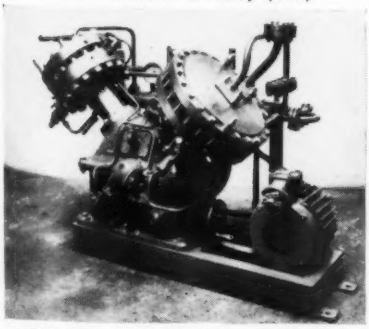
Reactor blowers at Mol (168)



Remote controlled microscope (185)



Finned tubes in Zircaloy (197)



Glandless diaphragm compressor (250)

Rich. Seifert (217)
Pneumatically and electrically operated remote-control industrial gamma radiography units.

FRANCE

Commissariat à l'energie Atomique (220)
Part of the stand will provide a general introduction to atomic energy. The other part shows France's future plans to 1961, and includes illustrations of the work at her research centres, and uranium plants. Models of the Marcoule and EDF reactors.

HIGHLIGHTS

- ★ **Remote control microscope** Reichert
- ★ **Fast scaler** CDC
- ★ **Nuclear ship plans** France Atome
- ★ **Fast neutron chopper** Hispano Suiza
- ★ **Air-operated manipulator** ERTN
- ★ **Isotope separator** Gamma Industrie
- ★ **Ship propulsion plants** Bretagne
- ★ **Porous diaphragms** Metafram
- ★ **Vacuum metallurgy** Heraeus, Degussa
- ★ **Organic moderated reactors** Interatom
- ★ **Programmed vacuum system** Galileo
- ★ **Glandless pumps** Ratier
- ★ **Marcoule reactor details** Alsacienne, Hispano

Constructions radioélectriques du Centre (222)
A fast scaler with a resolution time of 0·2 microsec and a total store of 100 million counts. Wide-band and linear amplifiers and high voltage power supply units. A continuous recording air monitor for alpha, beta and gamma activity. A hand monitor which gives a reading in ten seconds —it uses a very large scintillation counter sensitive only to alphas.

Société Alsacienne (227)
Cooling gas throttling tube and plug of reactor G2, model of the charge mounting of reactor G2, dust activity detection equipment, electromagnetic pump, flow-meter and diagram of an experimental liquid metal circuit.

Combustible Nucléaire (227)
Manufacture of the fuel elements for the French reactors G1, G2 and G3 at the firm's Annecy plant. Shows uranium vacuum casting, rod cleaning, fluorimetric checking of the uranium content of the cleaning baths.

Ratier (230)
Wet-stator glandless pumps for heavy water and other primary coolants. On show will be a heavy water pump with a duty of 11 gpm against 83 ft head at 248 deg. F. Also a pump which can handle a mixture of heavy water and gas without damage to the motor.

Ets Tunzini (231)
Specializing in air conditioning and dust removal equipment, the firm have been responsible for air treatment at Electricité de France's first nuclear power station at Chinon. At Marcoule for the Commissariat à l'Energie Atomique they did the reactor control rooms and at Saclay the highly-active laboratories. At CERN Tunzini carried out the air conditioning for the proton synchrotron.

SAIP (234)
Proportional counter for low energy work down to 0·1 keV—uses beryllium window and has continuous gas purification. Also scintillation spectrometers, multi-channel kicksorters, scalers, ratemeters and counters of all kinds.

Sté d'Electricité Mors (237)
An electromagnetic door locking system developed for the Commissariat. Also relays, switchgear and other electrical equipment.

France-Atome (240)
This is France's largest nuclear group, comprising companies such as l'Air Liquide, Alsthom, Penhoët-Loire, Rateau, Société Alsacienne, Schneider, Thomson-Houston and many others. It is now ready to design and construct nuclear power stations anywhere. For the French CEA, group companies have built the G1, G2 and G3 reactors at Marcoule, the high-flux heavy-water materials testing and isotope producing reactor EL3 at Saclay.

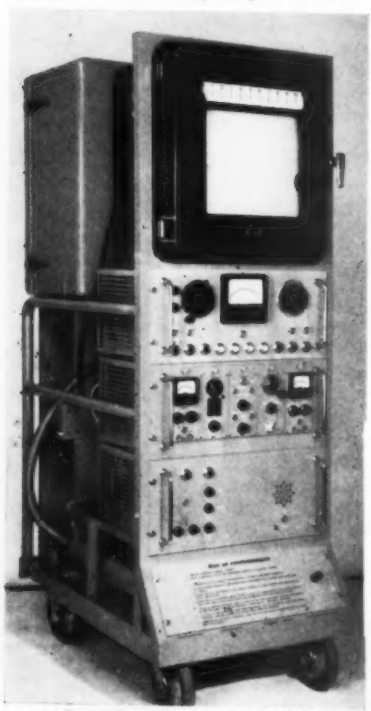
SNECMA (244)
The company started making aviation engines in 1905, and claims to be the oldest manufacturer in the world. Its atomic energy division is now studying gas turbine for nuclear propulsion and will show some of their work on high temperature gas cooled reactors and heat exchangers.

Hispano Suiza (247)
The working of a mechanical spectrometer for intermediate energy neutrons now in operation at Saclay will be demonstrated by a display panel. It uses a fast chopper which can be accurately controlled up to 15,000 rpm. The forged steel rotor has eight pairs of diametral channels and only neutrons above a certain energy can

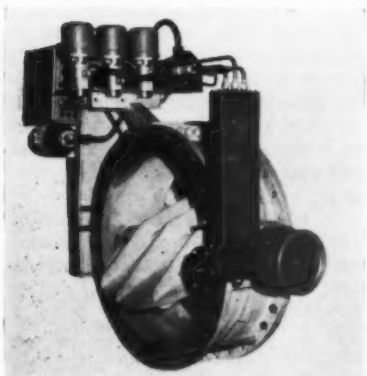
pass through at any given speed. For France's first commercial power reactor, EDF1, the firm show a fuel element charge chute. Other exhibits are: an hydraulically servo-controlled butterfly valve for gas circuits (in operation), the rotor of a seven-stage gas compressor, together with other mechanical items for nuclear purposes.

Atlrs et Chrs de Bretagne (249)
Details of an 18,000 hp turbine set for a nuclear powered ship, showing a novel type of shaft seal. Special type of dump condenser for nuclear ships with completely automatic control of dumping.

Sté Corblin (250)
Examples of the well-known Corblin compressor in which a metal diaphragm is actuated by oil pulsed under pressure from a reciprocating piston. Being glandless and leakproof, it can deliver oil-free any gas at up to 1000 psi. It can also be used with liquids.



Recording air monitor (222)



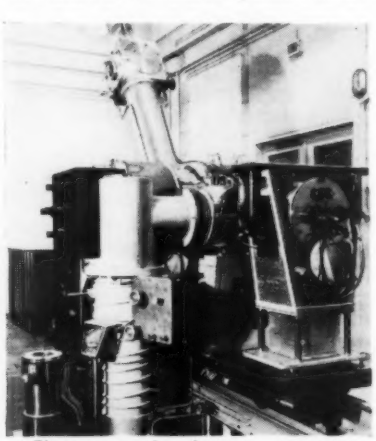
Remote controlled butterfly valve (247)

Metafram (253)
Boron carbide, boron control rods, sintered stainless steel diaphragms and filters of accurate porosity. Radiation-resistant bearings and other details in powder metallurgy.

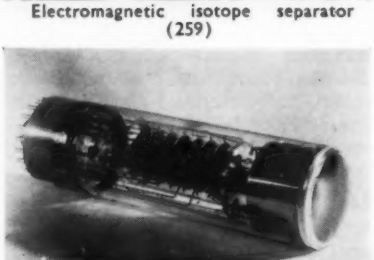
ERTN (255)
A pneumatically-operated remote control manipulator meeting Saclay requirements. Air operation is claimed to give flexible installation, low cost and freedom from maintenance troubles.

La Radiotechnique (256)
A photomultiplier tube with exceptionally short resolution time—it has a gain of 100 million and the output is linear up to 300 mA. Special optical systems and dynodes are used. Also other photomultipliers and three types of scintillators—zinc sulphide for alphas, plastic organic for betas, gammas and neutrons, polystyrene and zinc sulphide for fast neutrons.

Gamma Industrie (259)
The firm are licensees for the type EM2 electromagnetic isotope separator developed at Saclay. It is capable of separating, for example, more than 200 mg of lead isotopes in 24 hours. Other exhibits include the range of *Gammatron* industrial gamma radiography units, one model of which carries up to 20 curies of Co-60 and is trolley-mounted with hydraulic controls.



Electromagnetic isotope separator (259)



New photomultiplier tube (259)

Forges et Ateliers du Creusot (260)
Model of a spectrometer for 250 MeV electrons, now being built for the Ecole Normale Supérieur, Paris. Model of an armature for the CERN synchrocyclotron. Examples of stainless steel cladding and fabrication.

Vide-Touries (263)
A range of p.v.c. stopcocks with teflon linings suitable for chemical applications.

UCLAF (264)
Organic chemicals labelled with C-14, S-35 and tritium.

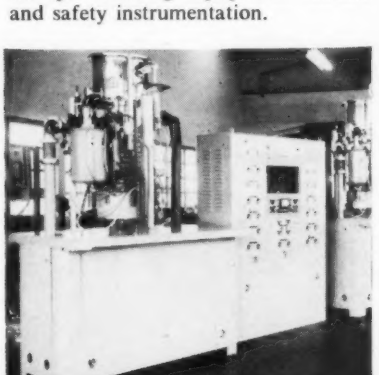
Quartz et Silice (266)
A wide range of scintillators, including: thallium-activated sodium or caesium iodide, zinc sulphide, organic plastic.

ITALY

Italettronica (273)
Fast multi-channel pulse analysers, scalers and autoscalers, d.c., linear and wide-band amplifiers, stabilized power supply units, geiger tubes and scintillation counters, portable survey meters, mass spectrometers.

Officine Galileo (272)
An hydraulically-operated programming unit for the automatic sequence control of high-vacuum systems. Also wide range of roughing pumps, oil diffusion pumps, baffles, valves and vacuum gauges.

Società Elettronica Lombarda (271)
Complete isotope counting apparatus for medical and industrial uses. Portable survey meters, geiger tubes, scintillation counters and ion chambers. Scalers and ratemeters, single- and multi-channel pulse height analysers. Isotope handling equipment. Health and safety instrumentation.



Laboratory vacuum plant (272)

REACTOR TEST LOOPS

4. Obtaining the results

by D. T. NORSWORTHY, A.M.I.E.E., Grad.I.Mech.E.
Project Engineer, Reactor Services Group, AERE, Harwell

The last article in this present series shows how loops are used and the type of information which can be got from them

ROUTINE TESTS ON SELECTED MATERIALS and components for a proposed reactor system are normally performed in in- and out-of-pile rigs, as described by Everson (*1*). However, if a reactor feasibility study results in the selection of an untried material for one of the three primary components of the reactor—fuel element, coolant or moderator—an in-pile loop is built which simulates the operating conditions of the proposed reactor as closely as possible. The main reason for this is that results obtained from static in-pile rigs and from out-of-pile experiments are not always a reliable guide to the behaviour of the selected materials when operating in a dynamic system in the presence of high intensity radiation. In addition valuable operating experience can be gained at an early stage in the development of the reactor on the handling of the new materials under active conditions.

TYPE OF INFORMATION REQUIRED

Before considering the methods used to obtain results from these loops we will examine in more detail the type of information which is being sought.

Coolant technology loops

In the study of a new coolant there are two main characteristics to be considered:

1. whether it reacts with any of the structural materials, the moderator or the fuel element canning material
2. whether the material itself remains stable under operating conditions and, if not, whether radiation induced changes make it unsuitable for use in the proposed system.

1. Compatibility of materials

To answer the first of these questions chemists and metallurgists will investigate the problems of corrosion, erosion at surfaces, deposition on surfaces and the combination of these effects which may lead to mass transfer from one part of the system to another. A typical example of a loop which was built primarily for this purpose is the PIPPA loop in BEPO (referred to previously by both Everson (*1*) and Fontaine (*3*)). This loop has been used to predict the extent and distribution of carbon transfer in reactors of the Calder Hall type.

When CO_2 gas is used as coolant in a graphite-moderated system a carbon-CO_2 reaction occurs at elevated temperatures resulting in the formation of carbon monoxide. This reaction is reversed at lower temperatures and as a result carbon from the moderator is taken up from the hottest region of the system and deposited on the colder surfaces, such as in the heat exchangers.

The reaction rate is also affected by the fast neutron and gamma flux intensity and by the geometry of the system. Hence the rate of mass transfer cannot be thoroughly investigated without simulating in a research reactor a complete reactor fuel channel and its equivalent out-of-pile coolant circuit.

An entirely different form of loop which has been used to investigate mass transfer effects is the simple thermal convection loop, illustrated in figure 1, for circulating

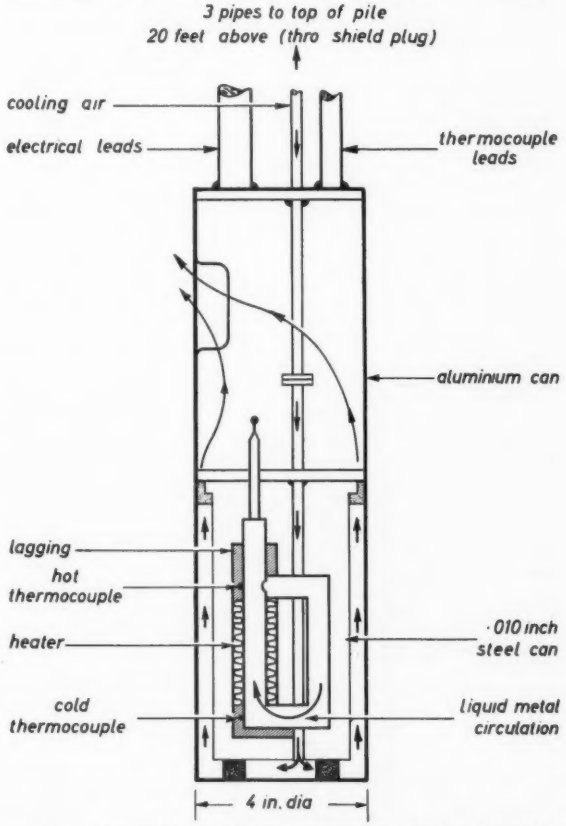


Fig 1 A number of thermal convection, uranium-bismuth loops of this type were built and irradiated in BEPO to investigate mass transfer effects. Length of the outer aluminium sheath is only 2 ft

a uranium bismuth solution. Liquid bismuth is one of the few materials which will take uranium into solution at temperatures low enough to permit its use in a homogeneous reactor system employing conventional steels for the main pressure vessel and other structural components. Unfortunately iron is also taken into solution by the bismuth and once again the saturation level is temperature dependent, resulting in mass transfer. Out-of-pile experiments showed that the addition of small amounts of magnesium and zirconium to the liquid metal solution prevented mass transfer by the production of a protective film of zirconium nitride at the surface of the steel. As a first step towards establishing whether or not the film would withstand reactor operating conditions a number of simple thermal convection loops of the type illustrated were built and irradiated at the centre of BEPO.

2. Coolant stability

To answer the second important question which will determine whether the selected coolant is suitable for use in the reactor it is necessary to establish:

- **a.** whether any radiation-induced change occurs
- **b.** what the rate of change is likely to be under running conditions in the reactor
- **c.** the way in which any change affects the physical and chemical properties of the coolant.

A typical example of a loop built to study coolant stability is the organic loop in BEPO, illustrated in figure 2.

One of the moderator-coolants being considered for a possible ship propulsion unit is an organic wax consisting largely of terphenyl ($C_{18}H_{14}$). This material has a low vapour pressure and allows the reactor to operate at a reasonably high temperature without requiring a high pressure system to prevent boiling. Under neutron bombardment the wax undergoes polymerization in which the molecules tend to combine together to form long chain 'phenyls,' at the same time releasing molecules of free hydrogen or hydrocarbon gases. The process also occurs, in the absence of irradiation, due to temperature alone, but neither the rate of polymerization nor the actual polymer form can be predicted accurately from out-of-pile tests or from static tests in-pile The polymerized wax possesses different physical properties from the parent material and experiments are being carried out to establish the concentration of polymer which is tolerable in a reactor coolant since this will determine the replacement rate necessary—one of the most important factors in the economics of this type of system.

Another instance where coolant stability and compatibility is of considerable importance is in the study of pressurized light water systems. Under the action of nuclear radiation water partially dissociates and free hydrogen and oxygen are produced. A back-reaction also occurs and if a sufficient quantity of free hydrogen is kept in solution the oxygen concentration can be minimized. The presence of free oxygen is undesirable since it tends to aggravate the corrosion of the mild steel walls of the system. 'Crud'—micron-size particles of mixed metallic oxides—is always produced to some degree in these systems in spite of efforts to minimize it by using demineralized and deaerated water. This tends to be carried round the circuit in suspension and to be deposited on heat transfer surfaces where it causes a deterioration in heat transfer properties. It also spreads activity round the circuit. The importance of investigating these reactions is illustrated by the fact that the transfer of active corrosion products to normally inactive regions is liable to be a limiting factor in the life of some light water cooled, power producing systems.

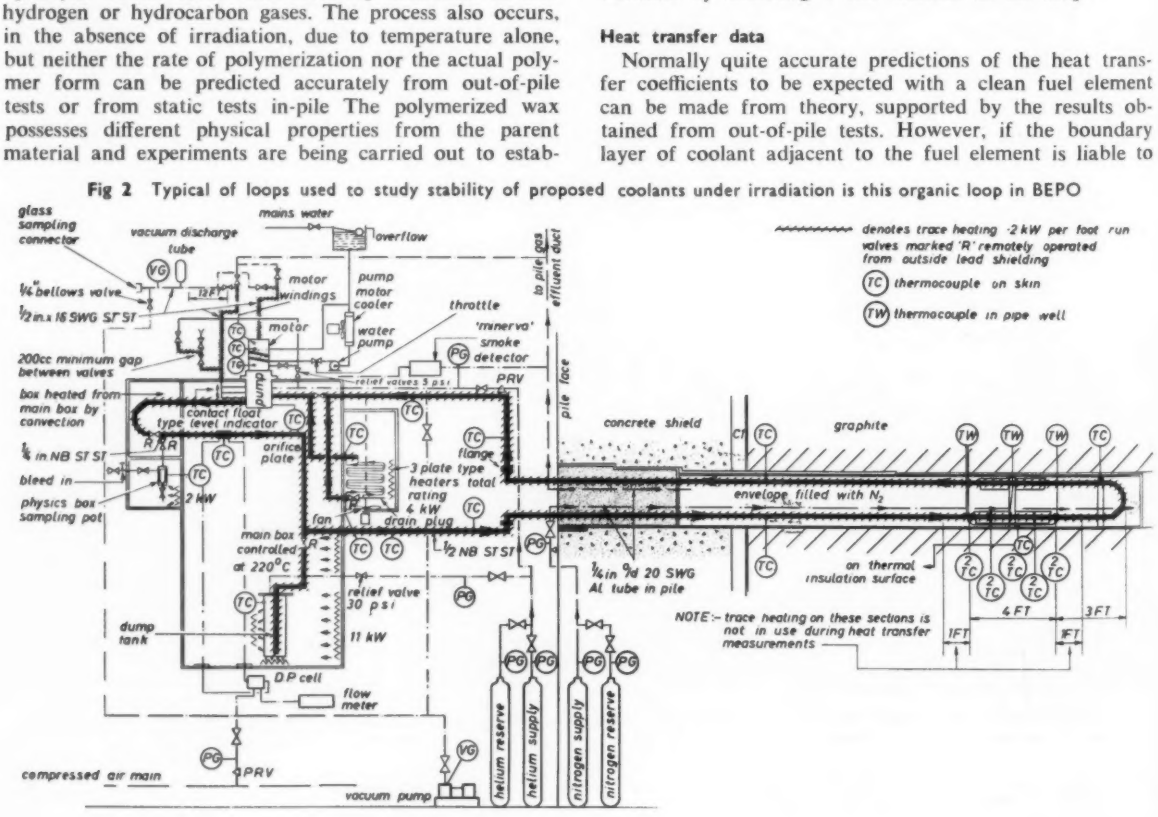
Fuel element testing loops

As explained by Everson, it is not possible to carry out a statistical analysis of fuel element life in a reactor test loop, due to the very large number of elements which would be required. Also it is rarely possible to test the fuel element finally chosen, as a component under its normal operating conditions, due to the serious depression of the thermal neutron flux which is produced by the fuel element and other loop components. But although proving trials on the fuel element cannot be carried out satisfactorily, a great deal of useful information can be obtained by including a fuel element in the loop.

Heat transfer data

Normally quite accurate predictions of the heat transfer coefficients to be expected with a clean fuel element can be made from theory, supported by the results obtained from out-of-pile tests. However, if the boundary layer of coolant adjacent to the fuel element is liable to

Fig 2 Typical of loops used to study stability of proposed coolants under irradiation is this organic loop in BEPO



change its physical properties, due to the action of the fission neutrons, heat transfer measurements must be carried out under high flux conditions. To achieve maximum possible heat flux at the fuel element surface, small diameter fuel elements highly enriched in U-235 are employed. Although the surface area: volume ratio is greater with a small diameter rod, this is more than offset by the smaller depression in thermal neutron flux due to reduction in size of the absorber.

Fission product behaviour

The way in which fission products are carried by the coolant, where they tend to deposit out and the ways in

Fig 3 In removing radioactive experimental equipment from one of the vertical holes in the top of BEPO a high-level crane is used and no shielding flask, relying on distance to provide the necessary protection

which they can be detected are still subjects which ultimately have to be investigated in reactor test loops. It is not always necessary, or indeed advisable, to use a full size defective fuel element for this purpose; a foil of exposed uranium of known size can be used to establish an equilibrium concentration of fission products in the system and this concentration can then be kept within acceptable limits. Factors governing the deposition of fission products are usually investigated in a by-pass circuit off the main loop. A vessel containing sample plates of various structural materials is provided with means of varying flow rate and temperature and of removing samples as necessary. Coolant sampling facilities for chemical analysis are normally provided on the same by-pass circuit.

METHODS OF OBTAINING RESULTS

Since the cost of providing a basic circuit, capable of producing conditions similar to those in the proposed system, is often high and the number of experimental holes available in the high flux research reactors is very limited, it is normal to build reactor test loops to give as much information as possible and they usually become multi-purpose tools available to more than one user.

The ways in which results are obtained from some of the loops previously mentioned will now be considered in more detail.

PIPPA model channel

Information on gas-graphite reactions is obtained from this loop by gas analysis and by removing and weighing graphite samples from the in-pile section. To take a gas sample from the system the all-glass sampling line is evacuated and flushed through with gas from the loop to ensure that the sample is representative and 200 cc of gas collected in a sample bulb. The relatively large sample taken makes it possible to analyse the carbon monoxide concentration to an accuracy of 2 vpm and the quantity taken is negligible compared with the total loop volume. Gas leakage from the system is bound to occur continuously and is has been found necessary to add carbon monoxide to the make-up CO_2 gas to maintain a true equilibrium concentration.

To remove graphite samples from the in-pile section the system pressure is reduced to one atmosphere and the primary circuit is broken at the pile face. The shield plug is removed and the graphite blocks which form the top half of the coolant channel are withdrawn. All handling of graphite is carried out with clean cotton gloves over surgical rubber gloves to prevent the possible transfer of contamination, which might catalyse the reaction, and provide protection for personnel. After removal from the reactor the blocks are left to decay for a period of four days before the graphite samples are removed for weighing. To ensure that the samples are weighed under comparable conditions at the beginning and end of a run they are heated to 180°C in an air oven for 18 hours and then allowed to cool in a desiccator. By this procedure the carbon dioxide trapped in the pores is replaced by air, a necessary precaution if a weighing accuracy of 0·1 milligrams is to be achieved.

After the channel has been reassembled and the primary circuit sealed the system is evacuated and then filled to a few atmospheres pressure with CO_2. This process of evacuation and pressurizing is then repeated twice more and a check made to ensure that the air content of the gas has been reduced to an acceptable level.

Uranium-bismuth thermal convection loops

Loops of this type are cheap and are regarded as expendable. They are irradiated for a definite period of time, unless drastic temperature changes indicate that serious plugging has occurred—this can be caused by mass transfer of steel or by uranium coming out of solution. They are then removed from the reactor to be cut open for metallurgical examination.

As shown in figure 1, the loop itself is very small and the outer aluminium sheath is only 2 ft long by 4 in. diameter. However, in order to locate this assembly at the centre of the reactor core, the complete pile element has a total length of over twenty feet. The provision of expensive shielded flasks for equipment of this length presents some difficulty and the normal procedure is to remove the complete assembly by means of a high level crane without a flask merely relying on distance to attenuate the radioactivity (figure 3). The loop is transferred to a vertical mortuary hole in the concrete floor adjacent to the reactor and left for a period of several weeks. At the end of this time the gamma activity has decayed sufficiently to permit handling for limited periods, using a portable 4 in. lead shield, containing a siting window, as protection. The loop is removed from its outer container, stripped of its lagging, electrical windings and thermocouples and placed in a flask for despatch to a special metallurgical laboratory. This laboratory is equipped with dry box facilities capable of handling equipment containing alpha-active material.

Water loops

As mentioned earlier these loops are used to study ways in which the transfer of active corrosion products can be minimized and to investigate fission product behaviour in pressurized light water systems.

Water quality can be determined by measuring either

pH or electrical conductivity since these two values are directly related provided the water chemistry is known. Conductivity is normally measured continuously and periodic samples are taken for pH measurement. The pH value is controlled by batch treatment of water from the loop in either of two mixed bed ion exchange columns. In one of these columns the hydrogen cation tends to produce a low pH while in the other an alkaline cation, such as potassium, will increase the pH value. For minimum corrosion in a mild steel system it is normal to run with high pH of between 10 and 11. The amount of corrosion occurring can be assessed by measuring the rate at which hydrogen is given off and also by activity measurement in the case of an in-pile loop. These methods can only give relative values however, since they presuppose that the rate of corrosion is uniform throughout the loop. They must be backed up by chemical analysis of the water and the examination of metallurgical specimens.

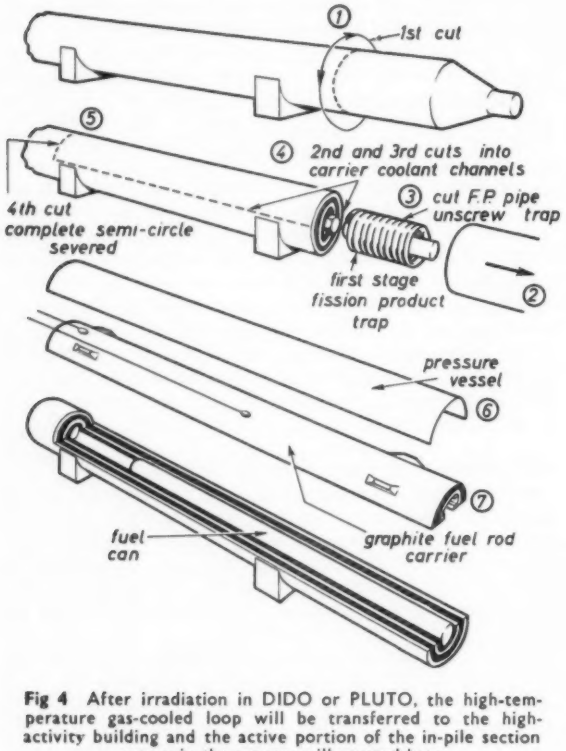


Fig 4 After irradiation in DIDO or PLUTO, the high-temperature gas-cooled loop will be transferred to the high-activity building and the active portion of the in-pile section cut up in the sequence illustrated here

The behaviour of fission products in these systems can be investigated by including a foil of exposed uranium, or a defective fuel element, in the high flux region of the loop and taking water samples from a point downstream of the source. The purpose of the work is to establish:

1. how large a defect can be tolerated in the fuel element.
2. the way in which fission products escape from a burst can.
3. methods of detecting a burst fuel element in the presence of the activity of water and impurities.

In order to obtain representative samples it is necessary to allow circuit water to flow through the sampling vessel for a period before isolating it and removing from the system. The point at which the sample is taken is also of some importance since the proportions of individual fission products present in a relatively cool bypass circuit is normally different from that in the main loop. The samples are used to determine the amounts of both gaseous and solid fission products present and also the Crud can be filtered from the water and analysed for fission products.

High temperature gas cooled loop

This loop is intended to investigate fuel element performance and stability and methods of scavenging fission products from a fuel element which consists of a cold-compacted sinter of graphite, uranium and thorium enclosed in inner and outer graphite tubes. Scavenging is carried out by extracting gas through the inner tube and the efficiency of the scavenging system determines the amount of activity which escapes into the coolant gas circuit. This activity will be checked periodically by taking gas samples while the loop is operating. The quantity of fission products escaping will be governed by the migration of the various elements through the outer graphite tubes and this will be checked, during the post mortem examination, by sectioning the can.

To demonstrate the normal procedure which will be followed when removing in-pile sections from reactor test loops, after irradiation in the high flux reactors DIDO and PLUTO, the proposed sequence of operations for the HTGC loops will now be described.

After disconnecting the out-of-pile equipment, the in-pile section is withdrawn into a horizontal flask which totally encloses the equipment in a 10 in. thick lead shield. It is then transferred to a storage block to decay for several weeks before being transferred again in the flask to the high activity handling building (*4*) for dismantling. The present proposed method for cutting up the active portion of the in-pile section is shown in figure 4.

The first stage fission product trap will be examined closely since it employs a comparatively new method of fission product removal. The fuel element, in addition to providing information on fission product diffusion through the can graphite, will be used to check whether any dimensional changes occur in the fuel rod. The physical constants of the graphite are also liable to change under fission product bombardment and these will be checked, particular attention being paid to thermal conductivity and coefficient of expansion.

Conclusion

The four articles in this series have given an indication of the problems involved in the design, commissioning and operation of reactor test loops in research reactors at Harwell. These loops are only one link in the elaborate study programme covering feasibility, economics and design, which is essential to the evolution of a new type of power reactor.

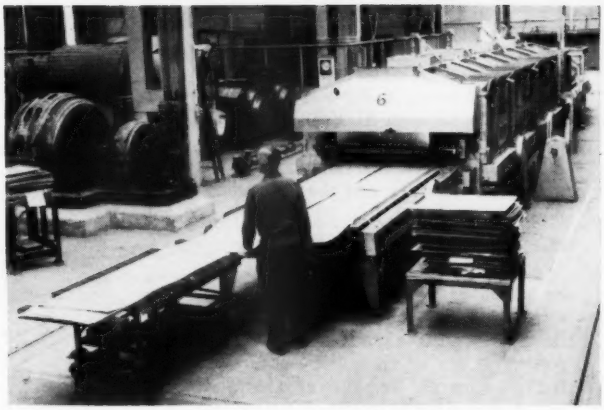
It is sometimes argued that the money and time expended on a major engineering loop is not justified, but wherever a new type fuel element or coolant is to be used information can be obtained from the loop which is vital to the design of a satisfactory small prototype reactor. Since the cost of these prototypes is high, even when compared with the maximum cost of a loop, it is obviously more economical to investigate the problems in a test loop and the success of the reactor experiment can be more readily assured.

References

'Reactor test loops'—previous articles in this series:
1. Everson, I. '1. Introduction' NUCLEAR POWER, 1958, *3*, June p 260
2. Hooper, A. T. '2. Design factors' *ibid*, July p 318
3. Fontaine '3. Testing and commissioning' *ibid*, August p 354
4. Dismantling hot test loops NUCLEAR POWER, 1958, *3*, March p 108

Titanium for chemical plant

ICI install new melting furnaces, build rolling mill



At the Waunarlwydd mill, titanium sheet is annealed at 1,000°C in this GWB continuous electric furnace

LAST MARCH, ICI Metals Division brought into operation at its Witton, Birmingham, Works the largest titanium melting furnace in Europe. This was one of three consumable-arc vacuum-melting furnaces supplied by W. C. Heraeus GmbH (Western Germany). Each is capable of producing ingots weighing up to 4200 lb. The furnaces were delivered in January and the first 1-ton ingot was produced a little more than two months later. Within a few days, an ingot weighing 4200 lb—the largest ever produced outside the US—was successfully melted. The electrodes are made by compacting powder produced by the Kroll process with sodium reduction at ICI's Wilton, Yorks, plant which has been operating since 1955.

Remote control

The new melting equipment incorporates the most advanced measures yet devised to ensure safe working. All operations are carried out by remote control and the furnaces themselves are installed in massive reinforced concrete cubicles affording complete protection. In the control room, optical systems give the operator a clear view of the furnace interior throughout the melting process.

In the last three years, technical knowledge on titanium has accumulated so rapidly that the Company has twice replaced its entire complement of melting furnaces. In 1955, eighteen furnaces were needed for an output of 1500 tons a year; today, three are sufficient to produce over 2000 tons a year.

Hot and cold rolling

After cooling, the ingot is 'dressed' to remove surface blemishes and heated under strictly controlled conditions for forging into slab or round billet. When the forged product has been machined to remove the oxidized layer it is again heated and then hot-rolled on breaking down mills to suitable size for processing into sheet or rod. Until recently, hot or cold rolling to finished gauge was carried out in the Witton factory on mills normally used for rolling copper and brass. As the cold rolling of titanium is appreciably more difficult than that of other non-ferrous metals, a considerable amount of work on copper and brass products was being displaced. To deal with this situation, the ICI Board sanctioned the building of a new plant at Waunarlwydd, solely for the rolling of titanium and titanium alloys.

But still expensive

UK output of wrought titanium, which was first marketed in this country in 1955, has until recently been absorbed largely by the aircraft industry, where the unique strength/weight ratio of the metal is of outstanding importance. But recent changes in defence policy have led to a reappraisal of the long-term requirements of the aircraft industry and to the view that titanium's largest potential output probably lies in its use for the construction of chemical plant, where its remarkable resistance to corrosion promises to effect some quite revolutionary changes. Current ICI prices are approximately: sheet, £6 per lb; rod £5 per lb.

Biggest data logger delivered in record time

A DATA-HANDLING SYSTEM with 2080 scanned points designed, built and delivered in eight months is the record achievement of Sunvic Ltd who have just completed the order for the UK Atomic Energy Authority. Shortly before the first units were delivered, *Progress* went down to Harlow to inspect the first units of the equipment which is claimed to be the largest data logger yet built in Europe.

The purpose of the equipment is the supervision of operations in a section of the Authority's gaseous diffusion plant at Capenhurst. In this, natural uranium in the form of gaseous uranium hexafluoride is pumped through porous walls contained in a great number of large cells of approximately 20 ft cube. In the course of this, the lighter 235 isotope diffuses faster than the heavier 238 and so a progressive enrichment in 235 is obtained. No details have ever been released of the Capenhurst plant but it is understood to cover several acres and involve hundreds, if not thousands, of cells, arranged in cascade.

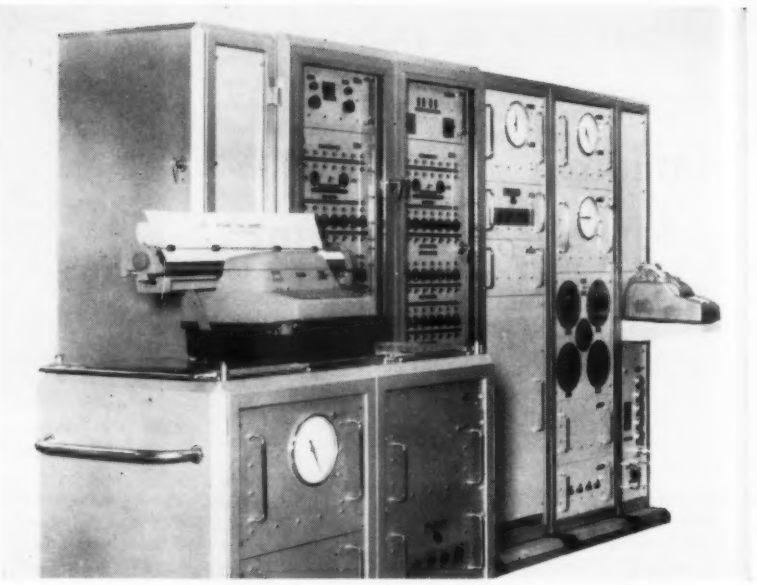
Close control is of great importance to the process which must be carried out at as low a temperature as possible but not so low as to reach the point (believed about 60°F) at which the hexafluoride changes from the gaseous state to the solid (it has no liquid phase). If this were allowed to happen the pumps and pipe would become plugged. The gas is pumped through each cell by eight water-cooled pumps driven by 250 h.p. motors.

The Sunvic logger consists of eight units, each of which contains four sub-units corresponding to cells. Thus 32 cells are covered by the apparatus. The measurements taken from each cell consist of: 16 gas temperatures (upper and lower limit) 8 pump gland temperatures (upper limit only) 16 motor bearing temperatures, 16 water cooling temperatures, 8 motor cur-

rents, 1 voltage—making 65 scanned points per cell. There is also one test point in each cycle. The complete cycle lasts 10 minutes and the accuracy of reading is ±0·5 pc. If any reading is off normal a visual alarm is given and an alarm printer built into the unit records time, identification and reading at the offending point.

Mobile Units

At the plant, the scanning units will be mounted on top of the diffusion cells they are monitoring but from them will pass signals to a central control room which will be equipped for printing on demand a tabulated log showing the value at all points of the quantity being measured, the point identification and the time. Additionally two mobile print-out units are being supplied. Equipped with electric typewriters they can be plugged into any given sub-unit and the operation of the relevant cell studied in detail on the spot, as the complete data—normal or otherwise—is printed out.



Logger consists of eight of these cubicles, each containing four units and an alarm printer. There are also two mobile units—one is seen in front

As far as temperatures are concerned, the millivolt signals from the thermocouples are first taken through compensated wires to a reference cold junction and there transferred to the unit where they are switched in by input relays with platinum contacts, the scanning being done by uniselectors driven by a timing circuit. The millivolt signal is now passed to an input servo consisting of a self-balancing potentiometer with a retransmitting slidewire and tachogenerator feedback. This produces an a.c. output signal in the 6 V range which is used for limit detection, the actual limits being preset manually. For further data processing, the signal is fed to an output servo which is similar to the input unit except that it incorporates a shaft digitizer which converts the signal from an analogue to a binary number. The final step is a decoder which turns the binary number into a decimal number suitable for relaying through the output scanner to the off-normal printer.

In the case of the motor current signals, they are transformed down to a millivolt analogue and then treated as the temperature readings. The whole unit is sealed and kept at about +2 in. w.g. to ensure that no dust can enter. In the case of a failure of the automatic scanning, full manual control is also provided.

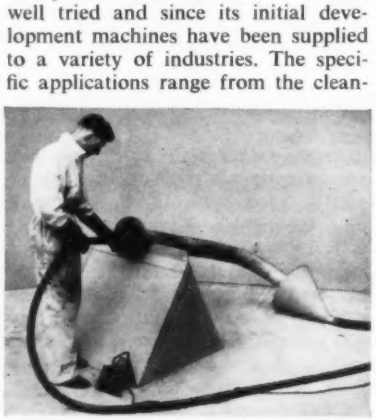
The contract for this equipment was placed with Sunvic only in January and the first units were delivered to the Authority early in August.

Novel approach to an old problem—tube cleaning

IN RECENT MONTHS Vacu-Blast Ltd have developed a technique for cleaning internal surfaces of tubes. It's claimed that a small range of simple attachments enables the cleaning of practically any shape or size from ¼ in. bore upwards. The essential part of the equipment is the Vacu-Blast machine itself. Incorporating a pressure/vacuum system for abrasive feed and recovery with a thorough segregation of grit, slag and dust, the system lends itself to adaptation for tube cleaning which has been a recurring problem since the inception of industrial processes.

In effect the tube is used to replace the Vacu-Blast gun with the pressure and vacuum hoses connected at opposite ends, the closed circuit being maintained within the tube body. According to the varying sizes of tube different methods are employed, it being impossible in the space available to detail these.

Although the method has only recently been introduced, it has been well tried and since its initial development machines have been supplied to a variety of industries. The specific applications range from the cleaning of high alloy heat treated tubing for nuclear power plant work, the cleaning of nimonic alloy tubes, steam and oil pipes for thermal power plant installations and chemical piping.



Special attachments for Vacu-Blast gun enable it to clean tubes of practically any size or shape

Of course, the cleaning speed varies quite considerably according to the nature and condition of the tube to be cleaned, but in all cases the cleaning rate has proved to be surprisingly fast. A heat treated alloy steel tube bearing an exceedingly tenacious heat scale was cleaned thoroughly at a rate amounting to 40 sq ft per hour, whilst ordinary commercial mild steel piping might be cleaned at rates as high as 250 sq ft per hour. The cost of cleaning does, of course, vary pro rata to the cleaning speed and the cost range might vary from one penny per sq ft on commercial piping to about tenpence per square foot on heat treated alloy steel.

In addition to the simple attachments mentioned above, a more specialized item has been developed for cleaning large bore straight tubes.

New Product Survey

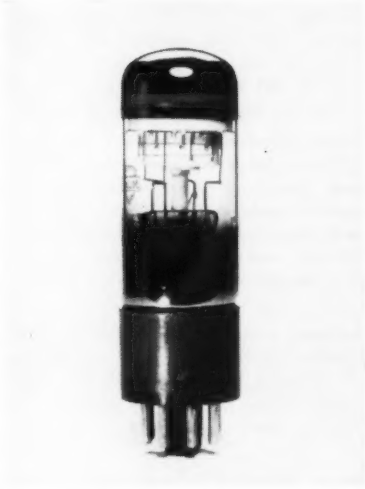
PLANT · EQUIPMENT · INSTRUMENTS · MATERIALS

DECIMAL COUNTER TUBES

Free from photoelectric effects

Two cold-cathode decimal stepping tubes have been introduced by Mullard Limited. They are the Z303C counter tube, which is equivalent to British Services type CV2271, and the Z502S selector tube, equivalent to British Services type CV2325.

A feature of the tubes is their freedom from photoelectric effects, the ignition characteristics remaining constant during daylight and darkness. Maximum



Counter tube is on international octal base

counting rate for both tubes is 4·0 kc/s. Normal operating current is approximately 340 microamps at a supply voltage of 475V. Applications for the counter tube include nucleonic scalers, counting devices, frequency dividers and timers. The selector tube is suitable for industrial batching equipment, welding control gear, electronic tachometers, telemetry equipment, computers etc.

Tick **No 191** on reply card

GAS REFRIGERATION MACHINE

Includes N_2 liquefaction

An addition to the range of the Philips gas refrigerating machine, is announced by their sole distributors Research and Control Instruments Ltd. This new model (PW 7050) incorporates a nitrogen separation column, by which means air can be liquefied and separated at atmospheric pressure to produce four litres of liquid nitrogen per hour. Continuous operation is possible for a period of one week before de-frosting becomes necessary.

It's believed the plant has many applications, including: vacuum traps, shrink fitting, hardening, annealing, accelerated ageing and low temperature techniques of all kinds.

Tick **No 192** on reply card

WELD CLEANING FLUID

Leaves bright matt surface

North Hill Plastics are now in a position to supply a new weld-cleaning fluid for use with stainless steel and certain high chromium and nickel alloys. Known as *Pelox*, the fluid is reported to be an outstanding success on the Continent and to have passed tests in the welding laboratories of important research organisations in this country.

The liquid is applied to the discoloured areas and the metal immediately polished with a rotating stainless steel brush which leaves a bright matt finish. Any residue from the dried-out liquid is simply removed with sponge and cold water. The liquid contains no skin irritants and, apart from polishing goggles, gloves and other protective clothing are not required.

The makers claim that 1 kg will clean over 2,000 feet of weld at a cost of about ¼ penny per foot. Additional advantages claimed are freedom from continued corrosive attack because the liquid is self neutralizing and stores indefinitely.

Tick **No 193** on reply card

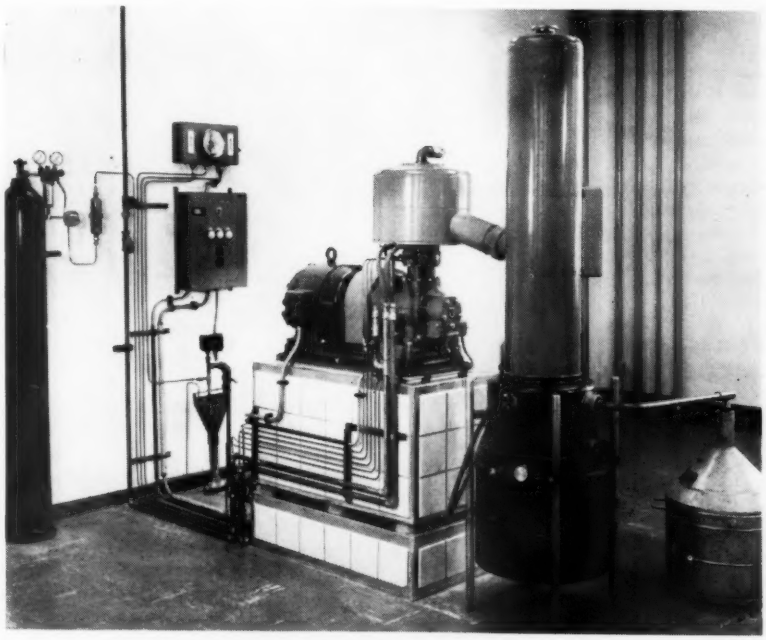
ALLOY STEEL GATE VALVES

Improved seatings

Langley Alloys have announced a detailed improvement in the design of their range of alloy gate valves which represents a large step forward in improving the shut-off power of the gate valve over much longer periods between maintenance, without the use of plastic, rubber or other non-metallic seatings.

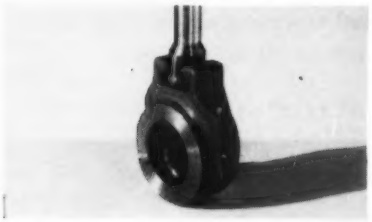
The improvement is obtained by specially machined faces on the wedge or gate of the valve. It is claimed that the life of the seating faces is more than doubled before re-seating is necessary, even when the valve is made in austenitic stainless steels and the wedge and body seat facings are of the same alloy quality. Moreover, a complete and positive shut-off is achieved even when body movement takes place as a result of temperature variations or line stresses and even when slurries are handled or foreign matter is present in the fluid.

Extensive plant tests of *Multi-seal* valves on the most difficult services have been carried out over the past two years



Philips' new liquefier is completely automatic in operation

in the chemical and petrol-chemical industries and have proved these features in valves on liquid, gas and vacuum duties over a very much wider range of temperatures than has yet been possible with plastic-seated or other non-metallic



Seating face has concentric annular lands with grooves between

seated valves for extended periods.

Materials available include Langalloy 1V and 3V 18/8 stainless steels, Langalloy 20V special stainless alloy, Hidurax 1 aluminium bronze, and Langalloy special nickel alloys to order.

Tick **No 194** on reply card

VALVE VOLTMETER

Marconi cut costs

A vacuum tube voltmeter, Type TF 1300, at a very low price, is the latest addition to the range of voltmeters produced by Marconi Instruments.

The a.c. measurement range is 0·1 to 100 volts, 20 c/s to 300 Mc/s. It measures d.c. up to 300 volts and resistances up to 5 megohms. The indicating meter is direct-reading on a.c., d.c. and ohms ranges, and no correction factors are necessary. Zero stability is of a high order with respect to both time and mains variation, and only one zero setting is required for all a.c. or d.c. ranges. Both a.c. and d.c. inputs are isolated from chassis.

A radically new concept in mechanical simplicity has been introduced in this instrument, enabling costs to be cut whilst maintaining a high standard of performance.

Tick **No 195** on reply card

FLAMEPROOF PUMP MOTOR

Passes Buxton test

First shown at the recent Chemical and Petroleum Exhibition in London a flameproof motor has been added to the present range of Worthington-Simpson *Monobloc* chemical pumps. The new totally-enclosed fan-cooled, squirrel-cage induction motors have been designed to meet Groups I and II gases and comply fully with BS229:1957 for flameproof enclosure and BS2613:1957 for electrical performance. The sizes range from 1 hp to 7½ hp, 1,450 rpm and 1½ hp to 12½ hp, 2,900 rpm.

In addition to maintaining the principal features of the *Monobloc* design, the motor enclosure is of substantial construction so as to withstand rough usage and the arduous conditions under which flameproof motors may be called to operate. A prototype machine has passed its Buxton Test and the Flameproof Certificates which are issued by the Ministry of Power are in the course of preparation.

Tick **No 196** on reply card

DIGITAL DISPLAY UNITS

Has high visibility

Available for the first time in England is a new unique in-line digital display unit manufactured by Counting Instruments Ltd.

Each unit comprises a system of lenses whereby a figure or letter is projected on to a screen by means of twelve lamps. The main advantage is that the image always appears in the same plane, giving a very wide angle of view. The units can be banked together to give, for example, the read-out on a digital voltmeter, though numerous other applications exist. The large illuminated figure 1in. by ⅝in. gives high contrast for perfect visibility. The standard model has

Letter always appears in same plane, giving wide angle view

provision for projecting the figures 0-9 and two decimal points.

A number of other models are being developed showing letters, signs, and provision for either coloured characters against a black background or a coloured outline to a white character.

Tick **No 197** on reply card

IN BRIEF

Valve voltmeter New unit from Winston Electronics measures d.c. and a.c. without bleeding the circuit. Centre or left-hand zero available.
Tick **No 198** on reply card

Welding transformers New range (LWM) of multi-operator units with inbuilt p.f. correction capacitors by English Electric. Also portable trolley-mounted rectifier unit (type LWD 350).
Tick **No 199** on reply card

Flash tester Airmec have produced 100 kV unit for high voltage testing of materials with safe remote control operation.
Tick **No 200** on reply card

P.M. motor From R. B. Pullin and Co, a new addition to their range of international size 18 permanent magnet motors. It's also available as a high-sensitivity tachogenerator.
Tick **No 201** on reply card

Argon chromatograph At Gas liquid Chromatography Symposium in Amsterdam recently W. G. Pye and Co's new model showed a sensitivity 100,000 times better than previously attainable. Can be used by non-specialists.
Tick **No 202** on reply card

Bellows joints Now available from Samson Controls Ltd, they use bellows of seamless copper bronze alloy supported inside and out by sleeves.
Tick **No 203** on reply card

Speed deviation recorder From Evershed and Vignoles the MC/RP21 uses a tachogenerator operating a recorder backed off against a preset potential.
Tick **No 204** on reply card

Ultrasonic cleaning Large-scale equipment from Electro-Chemical Engineering uses barium titanate crystal transducers in conjunction with vacuum system which, firm claim, improves cavitation.
Tick **No 205** on reply card

Handling tongs Improvements to standard Harwell models without affecting interchangeability announced by H. L. Instruments. Agents are General Radiological.
Tick **No 206** on reply card

Liquid level switch K.D.G. Instruments have developed new unit suitable for 1, 2 or 3 level operation.
Tick **No 207** on reply card

Heat extraction in power reactors—4

by G. BOXER, Ph.D.
Senior lecturer in applied thermodynamics, Birmingham College of Technology

The final article in this series is divided into two parts: the first deals with the estimation of pressure drops in the primary coolant due to the effects of fluid friction and change of density due to addition of heat; the second discusses the criteria governing the choice of a suitable primary coolant

FLUID PRESSURE DROP IN THE REACTOR CORE

Most of the fluid pressure drop in the primary coolant stream will occur in the reactor core for which the following mathematical treatment has been proved satisfactory. In other parts of the reactor system the fluid pressure drops may generally be evaluated with the aid of the laws of elementary fluid mechanics.

Figure 1 shows a duct with a small angle of divergence to obviate boundary breakaway, turbulence and additional pressure drop.

The effect of addition of heat in the core leads to a decrease in fluid density and thus to an increase in fluid velocity, i.e.

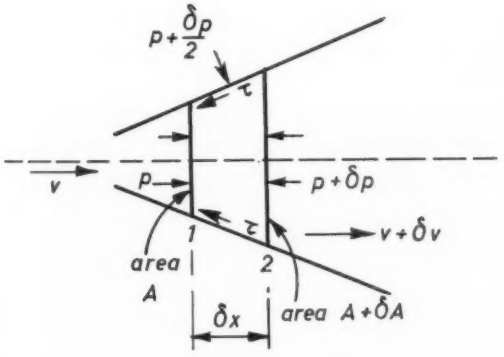


Fig 1 Forces acting on a fluid element

acceleration, in accordance with the mass continuity requirement. This fluid acceleration can only be achieved as a result of a pressure drop from channel inlet to channel outlet.

Thus there are two components of pressure drop in a reactor channel:

1. Component of pressure drop due to effects of friction.
2. Component of pressure drop due to effects of change of density.

Let τ in figure 1 be the frictional stress per unit area.

Then frictional force over a length $\delta x = \tau\,\delta x\,(P + \frac{dP}{2})$

where P = duct perimeter at section 1
$P + \delta P$ = " " " " 2.

Normal to the duct wall there will be a pressure force given by

$$\text{force} = (p + \frac{\delta p}{2}) \times (\text{Area normal to wall over a length } \delta x)$$

Thus we may formulate the momentum equation as follows:

$$\rho A v\left[(v+\delta v)-v\right] = pA - (p+\delta p)(A+\delta A) + (p+\frac{\delta p}{2})\delta A - (P+\frac{\delta P}{2})\tau\,\delta x$$

Thus neglecting second order quantities and cancelling where possible,

$$\delta p = -\rho v\,\delta v - \frac{P}{A}\tau\,\delta x$$

Introducing the concept of a hydraulic mean characteristic length D_m once again, in ordinary differentials we may say,

$$dp = -\rho v\,dv - \frac{4}{D_m}\tau\,dx \qquad \text{where } D_m = \frac{4A}{P}$$

The friction factor f is defined by the equation:

$$\tau = f \rho \frac{v^2}{2}$$

where $f = \phi (R_e)$ and depends upon the type of flow regime in the channel

and thus $$dp = -\frac{4 f \rho v^2}{2 D_m^2} dx - \rho v \, dv \qquad (1)$$

where dp is given in absolute units.

Note that the corresponding expression for pressure drop with an incompressible fluid is given by:

$$\frac{dp}{L} = -\frac{4 f \rho v^2}{2 D_m} \text{ for a length } L \text{ of channel.} \qquad (2)$$

A comparison of equations (1) and (2) reveals that the effect of heat addition in the core is to add a second term $-\rho v \, dv$ to account for fluid acceleration due to change of density. Introducing the mass velocity G ($= \rho v$) and rewriting (1) we may say,

$$dp = -\frac{4 f G^2}{2 D_m \rho} dx - G \, dv \qquad (3)$$

Digression on the friction factor f

A vast amount of research has been carried out to establish valid relationships for the value of f for flows past different types of surface and the following is a summary of the results in common use.

Clean smooth surfaces

For the range $3000 < R_e < 10^6$ Koo's relationship gives

$$f = 0{\cdot}00140 + \frac{0{\cdot}125}{R_e^{0{\cdot}32}} \qquad (4)$$

and for the range $5000 < R_e < 10^5 \times 2$

$$f = \frac{0{\cdot}046}{R_e^{0{\cdot}2}} \qquad (5)$$

Equation (5) is widely used in reactor design and is very conveniently related to equation (23) of Part 2 in this series (July), to give a simple expression which connects the Stanton number and the friction factor as follows:

$$S_t = \frac{f}{2} \qquad (6)$$

For the range covering Reynolds numbers up to approximately 10^7, Von Karman's relationship gives

$$\frac{1}{\sqrt{f}} = 4 \log_{10} (R\sqrt{f}) - 0{\cdot}4 \qquad (7)$$

Rough surfaces

Figure 2 shows diagrammatically the results obtained by Moody (*ASME*, 1944, p.671) where:

1. the friction factor used by Moody is equal to 4 times that defined above,
2. E = height of excrescence on the surface,
3. $\frac{E}{D}$ = relative roughness parameter (and D = tube diameter)

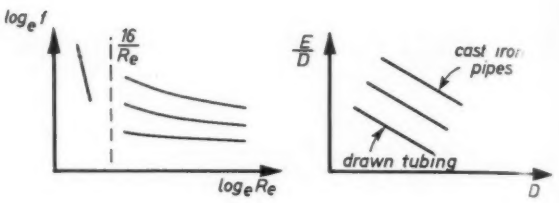


Fig 2 Friction factor f for rough surfaces (Moody's results)

The data given in this work can be used to cover conical pipes with small angles of divergence.

Derivation of Guggenheim's equation

Let dH = change of fluid enthalpy due to addition of heat, then a balance of energy in the channel gives

$$\frac{q P dx}{A G} = \text{heat input per unit mass flow} = dH + v \, dv \qquad (8)$$

Also for a perfect gas we may write $p = \rho R T$ and $dH = C_p dT$ and integrating between stations 1 and 2 in the channel

$$T_2 - T_1 = \frac{P}{C_p A G} \int_1^2 q \, dx - \left[\frac{v_2^2 - v_1^2}{2 C_p} \right] \qquad (9)$$

assuming that C_p does not vary along the channel.

Thus in equation (3) multiplying throughout by $2p$

$$2p \, dp = -\frac{4 f G^2 \, 2p}{D_m \, 2\rho} dx - G \, 2p \, d\left(\frac{G}{\rho}\right)$$

or $$2p \, dp = -\frac{4 f G^2}{D_m} RT \, dx - G^2 \, 2p \, d\left(\frac{RT}{\rho}\right)$$

as G is constant with respect to x

Thus $$2p \, dp = -\frac{4 f G^2}{D_m} RT \, dx - 2G^2 R \left[dT - T \frac{dp}{p} \right]$$

or $$p_1^2 - p_2^2 = \frac{4 f G^2 R}{D_m} \int_1^2 T \, dx + 2G^2 R \left[(T_2 - T_1) - \int_1^2 \frac{T}{p} dp \right]$$

If we now define $$T_m = \frac{1}{L} \int_1^2 T \, dx$$

and also $$\int_1^2 \frac{T}{p} dp = \int_1^2 T \, d(\ln p) = T_{m_1} \int_1^2 d(\ln p) = T_{m_1} \ln \frac{p_2}{p_1}$$

Then

$$p_1^2 - p_2^2 = \frac{4 f G^2 R L \, T_m}{D_m} \left[1 + \frac{D_m}{2 f L} \left(\frac{T_2 - T_1}{T_m} + \frac{T_{m_1}}{T_m} \ln \frac{p_1}{p_2} \right) \right] \qquad (10)$$

$$\text{Also } v_2^2 - v_1^2 = G^2\left[\frac{1}{\rho_2^2} - \frac{1}{\rho_1^2}\right] = G^2R^2\left[\frac{T_2^2}{p_2^2} - \frac{T_1^2}{p_1^2}\right] \quad (11)$$

Guggenheim's approximations

To simplify equations (10) and (11) the following approximations were suggested by Guggenheim.

1. The temperature distribution is symmetrical about mid-channel.

$$\text{Thus } T_m = \frac{1}{L}\int_0^L T\,dx = \frac{T_1+T_2}{2}$$

This approximation gives an exact value for T_m if the coolant temperature distribution along the channel is symmetrical about the straight line joining T_1 and T_2 (see figure 3). That is, a large number of cases are covered exactly. This assumption is justified in practice.

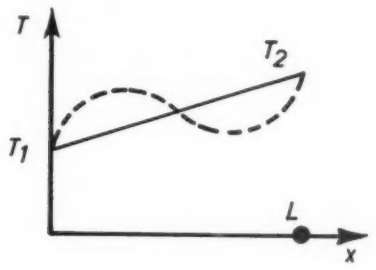


Fig 3 Guggenheim's first approximation for coolant temperature distribution in a reactor channel

2. Since the last term in equation (10) is small compared with the other two,

$$T_{m_1} = \frac{T_1+T_2}{2}$$

This is a rather cruder approximation illustrated by figure 4

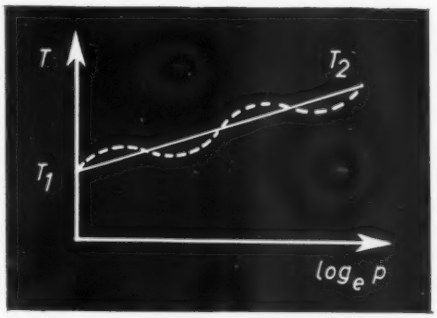


Fig 4 Guggenheim's second approximation

which shows a graph of T against $\log_e p$.
With these approximations equation (10) becomes

$$p_1^2 - p_2^2 = \frac{4fG^2RLT_m}{D_m}\left[1 + \frac{D_m}{2fL}\left(\frac{T_2-T_1}{T_m} + \ln\frac{p_1}{p_2}\right)\right] \quad (12)$$

or

$$1 - \frac{1}{r^2} = \frac{4fG^2RLT_m}{D_m p_1^2}\left[1 + \frac{D_m}{2fL}\left(\frac{T_2-T_1}{T_m} + \ln r\right)\right] \quad (13)$$

where $r = \dfrac{p_1}{p_2}$.

Equation (13) is known as Guggenheim's equation.

Solution of Guggenheim's equation

With reference to figure 5, we are given the conditions at station (1) and we have to determine v_2, T_2 and p_2 using equations (9), (11) and (12). Assuming for the moment that

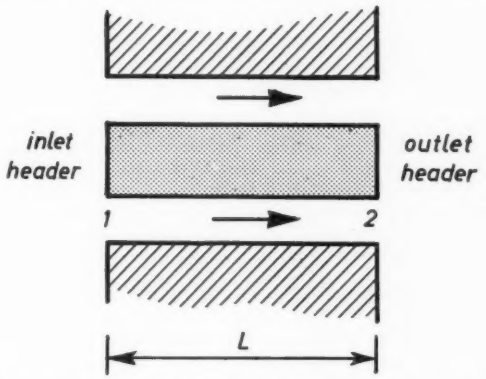


Fig 5 Configuration for solution of Guggenheim's equation

the fluid is incompressible, and using the modified form of the original differential equation (2), then from equation (9)

$$T_2 - T_1 = \frac{P}{C_p A G}\int_0^L q\,dx \quad (14)$$

Also from equation (11) $\qquad v_2 = v_1 \quad (15)$

$$\text{Also from equation (12) } p_1^2 - p_2^2 = \frac{4fG^2RLT_m}{D_m} \quad (16)$$

Thus we can get a first approximation to T_2 and therefore T_m from equation (14) and also to p_2 from equation (16). We now substitute into equation (11) to give a first approximation to the value of $(v_2^2 - v_1^2)$.
We may now use equation (9) to give a second approximation to the values of T_2 and T_m. Furthermore, we may substitute these values into equation (12) to give a second approximation to the value of p_2. (Note that in this instance it is feasible to use the first value for p_2 in the term $\ln \dfrac{p_1}{p_2}$ on the right hand side of the equation.) Finally we substitute into equation (11) again to give a second approximation to the value of $(v_2^2 - v_1^2)$. Normally two approximations using this reiterative process are sufficient to give reasonably accurate values for v_2, T_2 and p_2.

Once the values of p_1 and p_2 are determined, then the pumping power may be obtained by multiplying the volume flow of coolant by the change in pressure from p_1 to p_2.

CHOICE OF PRIMARY COOLANT

We may divide our discussion of the governing criteria for the selection of a suitable reactor primary coolant into two distinct parts:

1. *Nuclear properties of the coolant*
2. *Thermal properties*

It will be seen by the following discussion that the choice of a suitable coolant is restricted to a narrow range of fluids.

1. *Nuclear properties.* The two main considerations are the values of the absorption and scattering cross-sections σ_a and σ_s. A low value is desirable to preserve neutron economy and it is also desirable that excess neutrons are used with fertile material.

There are two cases to be considered here:

a. Fast reactor—no energy reduction is required. Thus σ_s must be low.

b. Thermal reactor—high values of σ_s are desirable. Since thermal neutron energies are required, the coolant should have moderating properties as well.

In thermal reactors a good moderator is achieved with a high value of the moderating ratio

$$\frac{\sigma_a}{\sigma_s} - Z.$$

In the event of mechanical failure and loss of coolant, the reactor should automatically shut down, i.e. the coolant must be a moderator more than a capturing medium (absorber). This is strictly a problem for the physicist (see figure 6).

2. *Thermal properties.* There are two governing requirements:

a. a large heat output from the system which implies a high heat rating.

b. a high thermodynamic efficiency, implying a high coolant temperature and also a low ratio of pumping power to heat extracted from the core.

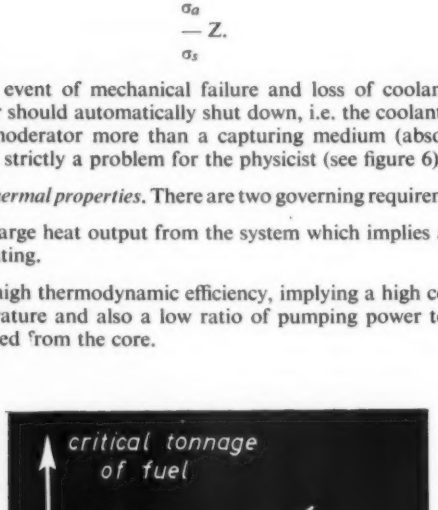


Fig 6 Nuclear properties of the coolant
Operating point (e.g. B) should be to the left of minimum point A. Loss of moderator atoms (i.e. loss of coolant) then leads to an undercritical system at C

Comparison of coolant properties

The following basis for comparison is suitable for judging the properties of one gaseous coolant with another or one liquid coolant with another, but not a gaseous coolant with a liquid.

Let h_p = pumping power = (volume flow of coolant) × (pressure drop)

Then $$h_p = mC_p\,(T_2 - T_1)$$

where in isentropic pumping (ideally), $$\frac{T_2}{T_1} = \left[\frac{p_2}{p_1}\right]^{\frac{\gamma-1}{\gamma}}$$

Thus $$1 + \frac{T_2-T_1}{T_1} = \left[1 + \frac{\Delta p}{p_1}\right]^{\frac{\gamma-1}{\gamma}}$$

or $$\frac{T_2-T_1}{T_1} = \frac{\gamma-1}{\gamma} \times \frac{\Delta p}{p_1}$$

(assuming $\frac{\Delta p}{p_1}$ is small, which is axiomatic for reactors).

Thus $$T_2 - T_1 = \frac{\gamma-1}{\gamma}\,\Delta p\,\frac{T_1}{p_1}$$

or $$\frac{T_1}{p_1} = \frac{1}{\rho_1 R} \text{ and } R = C_p\,\frac{(\gamma-1)}{\gamma}$$

Thus $$\frac{T_1}{p_1} = \frac{1}{\rho_1}\,\frac{\gamma}{\gamma-1}\,\frac{1}{C_p}$$

Therefore $$\frac{\gamma-1}{\gamma}\,\Delta p\,\frac{T_1}{p_1} = \frac{\Delta p}{\rho_1 C_p}$$

or $$C_p\,(T_2 - T_1) = \frac{\Delta p}{\rho_1}$$

Thus $h_p = \frac{m\Delta p}{\rho_1}$ = (volume flow) × (pressure drop at pump inlet)

where ρ_1 is the fluid density at pump inlet.

Thus $h_p = Av\,\Delta p = Av\,\frac{4fL}{D_m}\,\frac{\rho v^2}{2}$ (neglecting the fluid acceleration term).

also Q = reactor heat output = $Av\,C_p\,\theta_T$

Eliminating v between these two equations we get

$$\frac{h_p}{Q} = \left[\frac{2fL}{D_m A^2}\right]\left[\frac{Q^2}{\Delta T^3}\right]\left[\frac{1}{\rho^2 C_p^3}\right] \qquad (17)$$

The first term in equation (17) may be said to depend on the system geometry, the second on the thermodynamic fluid properties and the third on the ordinary fluid properties. Thus in comparing two gases or two liquids let us assume that we make the values of the first two terms in equation (17) the same in each case.

Then $$\frac{\left[\frac{h_p}{Q}\right]_1}{\left[\frac{h_p}{Q}\right]_2} = \frac{\left[\frac{1}{\rho^2 C_p^3}\right]_1}{\left[\frac{1}{\rho^2 C_p^3}\right]_2}$$

Thus on the basis of pumping power alone it will be seen that we desire a coolant to have the following characteristics:

1. A high value of h, the local coefficient of heat transfer.
2. A high value of $\rho^2 C_p^3$.

Radioactivity It is undesirable for a coolant to become radioactive. Additional shielding is expensive and extra maintenance costs are involved with activity of a long half life. Usually short half-life radiation is associated with high energy gamma rays.

Chemical compatibility Chemical action between the coolant and the moderator and other materials must be of a satisfactory low rate. Furthermore there must be no deterioration

in the coolant properties under high radiation doses and at high temperatures.

Stability It is undesirable for dissociation of the coolant into separate products to occur at the high values of temperatures associated with the reactor core when running at high power.

Special hazards The risk of explosion, fire and high pressure working must be considered when making a choice of reactor primary coolant.

Availability and cost The cost of initial equipment plus the cost of a secondary coolant circuit (in case the primary circuit becomes too radioactive), must be considered in addition to the cost of purification and pressurization equipment.

Liquid metals

Most of the liquid metals are eliminated as possible coolants by three factors: their melting point, their value of σ_a and their corrosion characteristics. Those left for consideration are sodium, potassium, lead and bismuth, together with sodium/potassium alloys and lead/bismuth alloys. Potassium has a higher σ_a than sodium and sodium/potassium alloys must be weighted correspondingly to allow for the different values of σ_a.

Values of moderating ratio for liquid metals

K	0·02	Na	0·90	Pb	0·05
H_2O	0·50	Bi	5·80	D_2O	8000

Values of $\rho^2C_p^3$

$$(\rho^2C_p^3)_{Na} \simeq 6(\rho^2C_p^3)_K.$$

Sodium has higher values of h and k than potassium but has a melting point of 98°C. The latter value can be improved by alloying with potassium.

Radioactivity with liquid metals Na-23 has a 15 hour half life, giving off a 2·7 MeV γ ray which immediately implies that the entire external coolant circuit must be heavily shielded.

Further reactions are listed below.

K-41 + n → K-42 (12·4 h) + 1·5 MeV γ-ray
Pb-206 + n → Pb-207 (0·8 sec) + 1 MeV γ-ray
Bi-209 + n → Bi-210 + beta → Po-210 + alpha → Po-206
(5 days) (138 days)

The last reaction gives a polonium hazard in which Po-210 scatters itself by recoil on alpha emission.

Sodium in graphite In the cold state sodium enters the pores of the carbon giving an increase in the effective absorption cross-section of carbon. When the carbon is raised in temperature, a rapid expansion of the sodium inside the pores of the carbon leads to fracture of the carbon blocks. It becomes expedient, therefore, to sheath the inside surfaces of the graphite blocks with zirconium.

Ordinary water

Water is an excellent moderator but is a free absorber of neutrons. It becomes necessary, therefore, to use enriched fuel, e.g. in LEO the enrichment was 0·3 C_0. Reactor design is sensitive to water density since a high temperature coefficient of sensitivity is associated with good moderating properties, and there is a 25 pc change in density from the cold to the hot operating condition. This leads to two considerations:

1. Reactor start-up—careful start-up is necessary to release the large amount of activity stored in the control rods
2. Cooling down of reactor—with cooling, density decreases, and it is necessary to absorb the release of excess activity.

With ordinary water large heat ratings are possibly limited, however, by a maximum temperature of about 370°C at 200 atmospheres. This pressure is undesirably high and with 1500 atmospheres the maximum water temperature is limited to about 270°C.

Radioactivity with water There is a fast neutron reaction with O-16:

$$\text{O-16} + \underset{\text{fast}}{\text{n}} \longrightarrow \text{O-17} \xrightarrow{\text{p}} \text{N-16} \xrightarrow[7\cdot3\text{ secs}]{\text{beta}} \text{O-16} + 6\text{ MeV } \gamma\text{-ray}$$

The type of shielding used depends largely on the reactor design.

Chemical compatibility of water Water is very corrosive on uranium and sheathing is vital. Zirconium has been proposed for water cooled reactors.

Stability under irradiation Water decomposes to H_2, O_2 and H_2O_2, the amount of decomposition being determined by the amount of activity, temperature and other factors such as impurities in the water. This reaction is reversible. If excess H_2 is left it may diffuse into the pores of the steel pressure vessel giving hardening of material and fracture. In addition H_2 diffusion into uranium leads to embrittlement.

Special hazards To obtain a high value of h with water, high pressures are needed which imposes a safety problem in the pressure vessel design. It is important to bear in mind that the design of the pressure vessel is determined in part by the effect of steel embrittlement by H_2 diffusion. This problem is still being carefully examined.

Gaseous coolants

Four gases are available for consideration once the initial conditions have been satisfied: hydrogen, helium, nitrogen and carbon dioxide. The corresponding values of Σ_a in cm^2/cm^3 are given below.

$H_2 = 1{\cdot}78$ $\quad He \simeq 0$ $\quad N_2 = 9{\cdot}60$ $\quad CO_2 = 0{\cdot}0132$

Values of $\rho^2C_p^3$

With reference to figure (7) it will be seen that from the pumping power aspect hydrogen has distinct advantages.

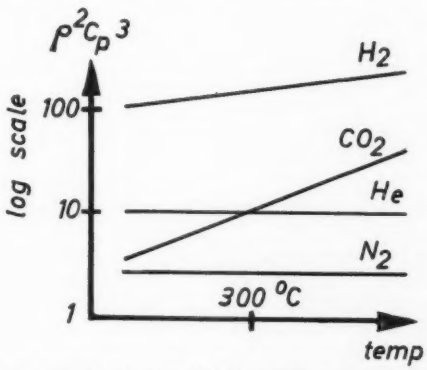


Fig 7 Values of criterion $\rho^2C_p^3$ for gaseous reactor coolants

However hydrogen has a large Σ_a as the gas expands and the system could become radioactive giving an adverse temperature coefficient of resistance.

Summary for gases

Hydrogen Excellent thermal properties; low pumping power; explosion hazard and fire risk; diffusion problem; probable coolant of the future.

Helium Good thermal properties; high pumping power; no chemical troubles as it is an inert gas; good nuclear properties; difficulty of obtaining large quantities in United Kingdom.

Carbon dioxide Low Σ_a, chemically compatible with carbon at Calder Hall temperature level; cheap to produce by well-established methods.

Cross Section by GRACCHUS

THE GREATEST single design restriction on heavy plant and equipment design is undoubtedly that of transport and the antiquated road system in this country has a lot to answer for in this respect. It is extremely sinister therefore to learn that just before the summer recess the House of Commons authorized a Ministry of Transport order completely banning 'abnormal or indivisible' loads on the new Preston bypass which is due to be opened in November. Certainly, the order is only a temporary one expiring in August '59 and Mr Watkinson assured the House that during this period he was prepared to authorize a certain number of oversized loads on the Preston road in order to study their effect on traffic flow. But I feel that this could well be the thin end of a wedge which could eventually bar all the new motorways—inc'uding the London-Birmingham and London-Yorkshire—to abnormal loads.

This must be resisted at all costs. Movement of such loads—and they are not, after all, everyday occurrences—is vital to heavy industry and with a properly planned movement they cause little inconvenience. In any case the Minister of Transport already has powers to regulate movement of abnormal loads on other roads without this peremptory ukase on the new arteries which were supposed to help industry.

IT WILL BE a proud moment for Sir Alexander Fleck when, in Glasgow's St Andrew's Hall, he rises to give his presidential address—*Science and Business—a Balanced Partnership*—to this year's British Association meeting on August 27. For it was in Glasgow that he started his career—as a lab boy at the University. Like Glaswegians Lord McGowan and Mr John Rogers, his two predecessors as ICI chairman, Sir Alexander certainly started at the bottom. Blinded by his more recent history and achievements, one is inclined to forget that Fleck was one of the pioneers of radiochemistry in this country and as long ago as 1913 obtained his doctorate for a thesis entitled 'Some chapters on the chemistry of the radioelements.' After three years as lab boy, Fleck became a full-time student, got his degree and soon had his own laboratory as physical chemist to the Glasgow and West of Scotland Radium Committee. With such a unique background of science and administration it is small wonder that he was chosen to head the Windscale inquiries.

The BA this year—as befits its declared objects—is even more nuclear than ever and in addition to Sir Christopher Hinton's evening discourse on Aug 29—*Nuclear Power and the Engineer*—many well-known nuclear men are reading papers—Prof Emeleus on transuranic elements, Dr Allibone on thermonuclear power, Denis Taylor on nucleonics in power stations, J. Walker on reactor control and H. M. Finniston on the newer metals.

TALKING of Sir Christopher Hinton, I think it's a pity his excellent *ABC of Atomic Energy* talks are not being broadcast—or better still, televised—in this country. It is however available as a booklet from most bookstalls and is also being done visually in the weekly magazine *Illustrated*. The talks, I understand, have been or will be broadcast in 21 languages in the BBC overseas services which should certainly give him the biggest audience ever for a popular science feature.

Sir Christopher prefaces his talk by saying there is nothing more mysterious about atomic energy than there is about any other source of power. True enough, but how many people really understand ordinary chemical combustion although it is an experience within everyone's personal experience. Even boiler engineers for the most part, have very little idea of what is happening to the complicated chemicals they use. I, like most of us I suppose, have had the problem of explaining atomic energy to laymen and I find the greatest difficulty is not the protons and the neutrons but the basic concepts of energy, heat and power. Until these are grasped in some sort of way I find it is useless to get into the nucleus. Thus for nine out of ten laymen, I find that something on these lines is sufficient—'uranium—a very heavy metal—is peculiar stuff. If you get enough of it and arrange it in a certain way—not all in one lump—it gets hot and you use the heat to make steam. See?' Of course you always get the smart aleck who says why, but if he presses you can graduate him to the full works. Admittedly, my simple explanation doesn't get you very far when the question of radioactivity is raised but even here I find one can usually skate round the subject without wreaking too much havoc with science. Ideally, of course, every responsible citizen should have a basic understanding of such matters but it's my experience that only certain kinds of minds are capable of this and they're mostly scientists anyway. Still, I value Sir Christopher's brilliant try and am grateful to him for some useful analogues.

MOST OF US, I imagine, have at some time come up against the problem of the mystery product or process. Let me explain. For example there are quite a lot of fluids and preparations about which there are claimed to do certain things. You can have a complete demonstration and you can ask any question you like about it, except one—'what's it made of.' Now it's sometimes important to know this because the preparation might have unpleasant side effects which perhaps don't develop until some time after. Yet you cannot have the information: you must take it at face value.

I only mention this because I was interested to read the other day that Mr F. J. Errol, Parliamentary Secretary, Board of Trade, had told members of the Advertising Association that they really ought to tell their customers what their products contain. Certainly, one doesn't want merely to hand over a commercially valuable formula to one's competitors and a mere mixture of chemicals is not protectable by patents. But I'd have thought that there must be some form of legal protection available. Incidentally, engineering suffers from this phenomenon far less than other industries. Try, for example, to find out what's in practically any soft-drink, detergent or toilet preparation.

On Record

The Weapons Group has considerable experience in the criticality problems of solid assemblies of fissile material.

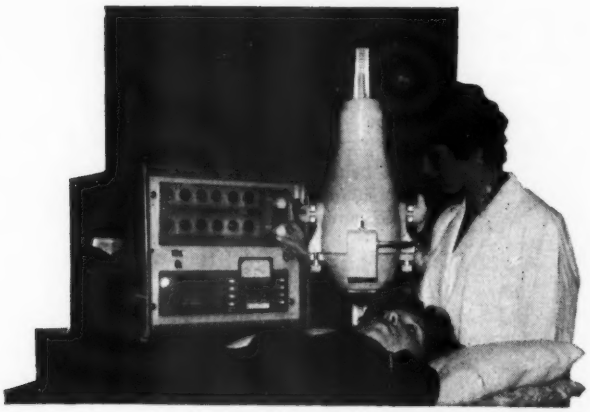
UKAEA 4th Annual Report

We make fresh water from sea water by atomic heat. We grind coffee by atomic heat. And we boil the stuff by atomic heat.

Lieut-Commander Paul Early, USS *Nautilus*

An 'intracellular detective,' an 'atomic farm' and a 'radioactive restaurant for rats' will be exhibited by the Argonne National Laboratory scientists at Geneva.

ANL statement



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INDUSTRIAL NEWSDESK

De Havillands go for HTGR

The de Havilland Engine Company has decided to concentrate its efforts on helping to develop a high-temperature gas-cooled reactor using ceramic fuel elements. A spokesman for the company says investigations into small highly-rated systems have shown that an HTGR could be designed which looked like being competitive with conventional plant for outputs in the region of 10-30 MWe. This and other 'potentially attractive' characteristics have led to a decision to make participation in its development a 'major objective' of the company. He disclosed that extensive research is already under way; a high-temperature gas loop has been designed and is under construction in collaboration with AERE, Harwell. It will be used to test a new type of ceramic fuel element in the PLUTO high-flux reactor, and the company hopes that experience gained will lead to a 'significant' increase in reactor operating temperatures. This in turn should result in higher specific heat outputs and an improved thermal efficiency. Since primary coolant temperatures as high as 800°C are regarded as entirely feasible it should become possible to give 'serious consideration' to the use of gas turbines to convert the nuclear heat into useful power.

Reaching for higher temperatures

Engineering tests in circuits and vital components under simulated operating conditions form an important initial stage in the development of any new reactor system. The de Havilland loop is concerned with in-pile testing where experimental equipment is inserted into one of the experimental holes of a research reactor—in this instance PLUTO—to determine the effects of radiation on the test specimen. The temperature of the element can be maintained at any desired value by controlling the flow of gas in the primary coolant circuit; in the initial experiments helium will be used. A secondary cooling system employing carbon dioxide has been incorporatd to provide adequate cooling in the event of a primary circuit failure. It should prevent overheating of the element caused by radioactive decay of fission products formed in the partially spent fuel. To ensure that no active material could escape into the reactor building in the event of a fuel element failure, all-welded components and circuits have been employed to give as high a standard of leak-tightness as possible.

Other work at de Havilland's associated with loop construction is the development and testing of small high-speed gas circulators; these incorporate self-acting gas bearings designed to obviate the need for lubrication and routine maintenance and experiments are being carried on to determine behaviour under simulated operating conditions and the best materials for their construction.

Fuse cuts power surge by 96 pc

A cylindrical 'safety fuse,' employing boron trifluoride gas for automatic reactor shutdown in emergency, was tested recently at the National Reactor Testing Station in Idaho, United States. The facility used was SPERT — Special Power Excursion Reactor Test—which is operated by Phillips Petroleum company, and the fuse prevented excessive power rise during a test in which the rate of power increase was tripling each one hundredth of a second. The power surge was held at a level 25 times lower than the reactor would have reached without the device, reports the Atomic Energy Commission. Total energy generated was cut by over 90 pc.

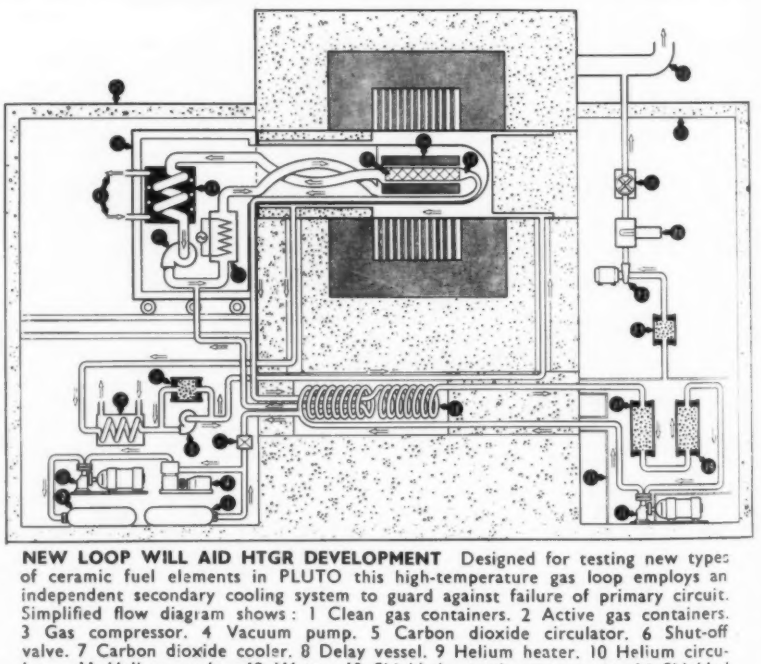
The device was developed by Atomics International as part of the AEC's safety programme. It was specially designed for pool type reactors, and requires no operator. A cylinder, part of which is in the core, is incorporated; the part outside contains boron trifluoride gas, and in the event of an excessively high level of operation this is automatically released into the lower end of the cylinder where it absorbs neutrons and brings the reaction under control.

Fresh look at the metric system

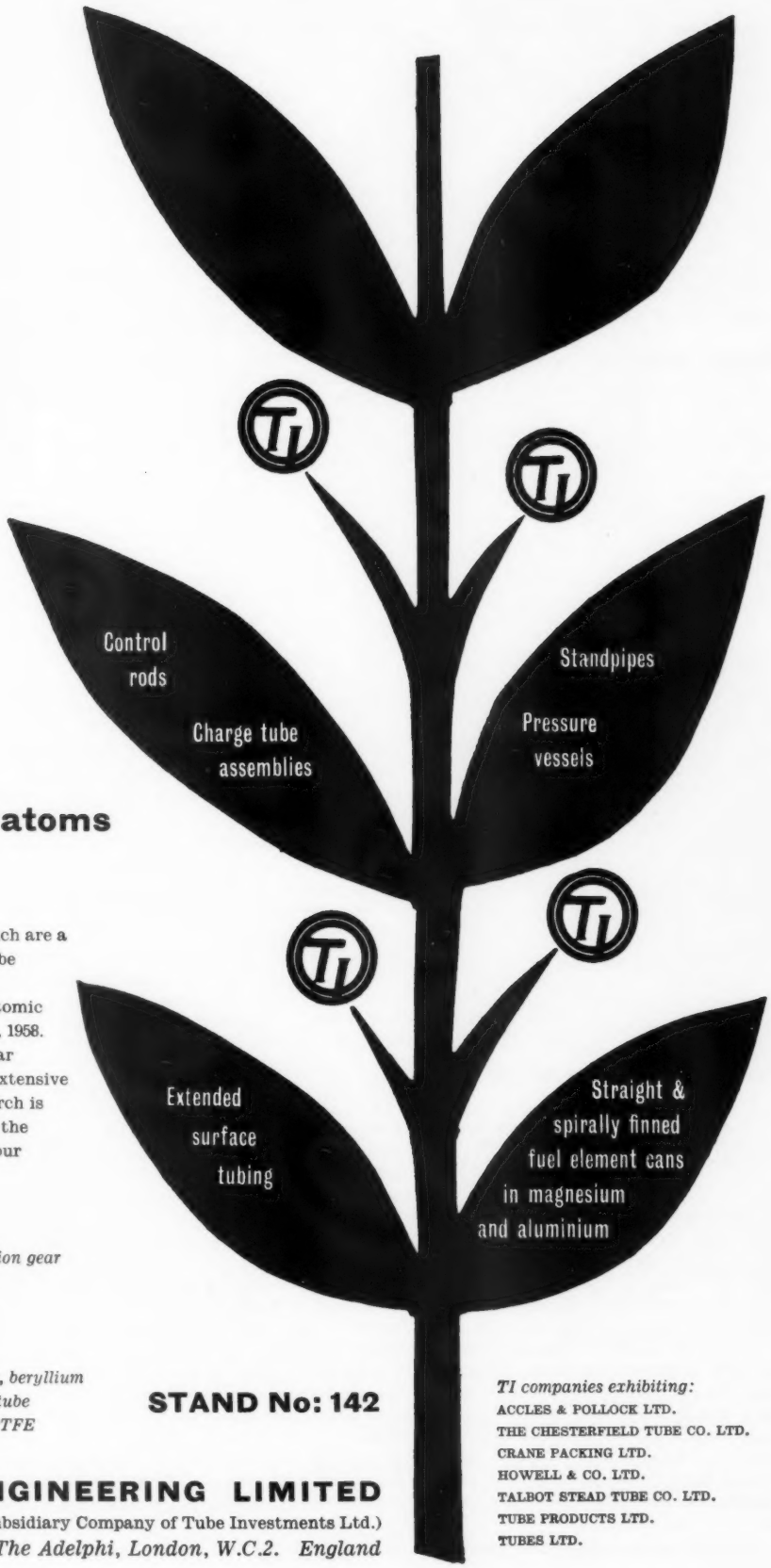
Would the long-term advantages of a changeover to the metric system in this country outweigh the transitional costs? This is one of the most difficult questions which a study group under Sir Hugh Beaver is attempting to answer. Set up by the British Association for the Advancement of Science the committee's terms of reference are: 'To report on the practicability, implications, consequences both international and domestic, and the cost of a changeover to the metric system or the decimalization of weights, measures and coinage by the United Kingdom.' A cross-section of industry is being approached with the co-operation of the Federation of British Industries and the various trade associations, and a full report is expected in about 18 months' time.

New cut-off uses transistors

Control of the giant research reactor under construction near Sandusky, Ohio, US, will be helped by a new 'cut-off switch' developed by the Bendix Aviation Corporation. Bendix calls the transistorized electronic system 'power-limiting' equipment, because it will



NEW LOOP WILL AID HTGR DEVELOPMENT Designed for testing new types of ceramic fuel elements in PLUTO this high-temperature gas loop employs an independent secondary cooling system to guard against failure of primary circuit. Simplified flow diagram shows: 1 Clean gas containers. 2 Active gas containers. 3 Gas compressor. 4 Vacuum pump. 5 Carbon dioxide circulator. 6 Shut-off valve. 7 Carbon dioxide cooler. 8 Delay vessel. 9 Helium heater. 10 Helium circulator. 11 Helium cooler. 12 Water. 13 Shielded containment rooms. 14 Shielded trolley box. 15 Flexible connector. 16 Ceramic fuel element. 17 Gaseous fission product take-off. 18 Graphite heat shield. 19 Exhaust gas duct. 20 Shut-off valve. 21 Activity monitor. 22 Exhauster fan. 23 Fission product delay vessels. 24 Gas purifier. 25 Secondary containment vessels. 26 Compressor. (More information on this test loop is given in the article on p 431)



We know our peaceful atoms

The products named on the olive-branch are a few of those which TI companies will be showing at the Second International Exhibition for the Peaceful Uses of Atomic Energy: Geneva, 1st—14th September, 1958. TI has been part of the story of nuclear engineering since the beginning. An extensive programme of development and research is widening the service we offer. Among the other products which can be seen on our stand are:

Graphite restraint bar assemblies
Tubular equipment for burst slug detection gear
Charge tubes · Header tubes
Pressure cylinders · Tubular forgings
Special-purpose tubes in alloy steels, stainless steels, zirconium, niobium, vanadium, titanium, tantalum, beryllium
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'detect and warn of any abnormal condition in the reactor, and automatically shut it down if safety requires it.' The equipment, which is auxiliary to the reactor's regular control system, is said to be 'more rugged' than non-transistorized types. It includes over a hundred transistors and is housed in a box 'smaller than a conventional refrigerator.' The 60 MW reactor is being built by the National Advisory Committee for Aeronautics to test and study the effects of radiation on materials that might be used in nuclear aircraft.

Round 2 BSD gear on the way

Greater compactness is the main feature of Dowty Nucleonics' new burst slug detection equipment, on show for the first time recently at their headquarters at Brockhampton Park, near Cheltenham. Known as the Mark Ia precipitator, it is intended for use in round 2 stations. Rotary valve, precipitator unit and controls are now incorporated in one cabinet instead of the two separate ones of the Berkeley equipment (NP, March 1958, p 119). This amalgamation has been made possible by an improvement in the scintillation counters and by the fact that the CEGB have set the maximum permissible radiation level in the BSD rooms at a lower value as well as by improvements in geometry. There are also improvements in the pneumatically-driven collector wire and the seventy feet of clean wire is stored compactly in the pressure vessel on two multigroove drums. The wire itself is multistrand twisted stainless steel—the exact specification is still a secret—and has a four-year life.

In Dowty's new BSD equipment selector valve and precipitator are combined in one unit. Pressure vessel is now very much shorter than the mark I

Director and general manager of Dowty Nucleonics, Mr T. D. H. Andrews, revealed that the firm is working now on several studies for the first American gas-cooled project and were visited only last month by a delegation from the US. This work includes gas bearing compressors as well as BSD equipment.

Half-way on Hinkley shield

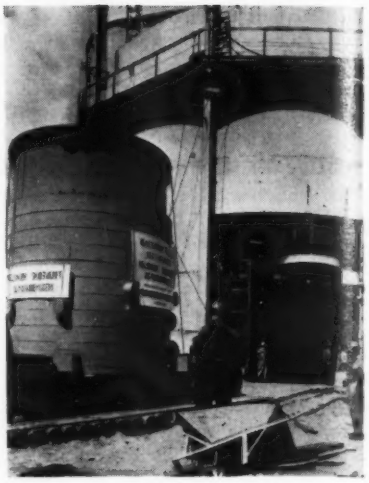
Construction of the main biological shield for the first reactor at Hinkley Point nuclear power station has reached the half-way mark. Work on the shield foundations began in mid-January, and after the use of about 13,000 cu yds of concrete it now stands 50 ft above ground level. About 1200 men are working on the site, and some 30,000 cu yds of soil have been excavated.

The starting date for the station was December 1957 and the initial task on the site involved the removal of 200,000 cubic yards of soil and clay excavation. By the use of fast-moving scraper equipment, this was practically finished by early January. To ensure all weather access to the whole site, roads and associated services were constructed rapidly, and most of them were ready by June. Extensive workshop and stores buildings have been built west of the main station site to provide facilities for site fabrication of heavy equipment such as steam raising units, reactor pressure vessel, etc.

70,000 sq yds reclaimed from sea

Reinforced concrete foundations are nearly complete for the 250 ft gauge track to carry the 240 ft high Goliath crane which will be capable of lifting 400 tons. Heavy plant and equipment will be brought from the works (in Scotland and the North) mainly by sea and to receive this a wharf capable of handling ships of up to 1500 tons has been constructed in six months at Combwich, about four miles from the main site. A 45-ton derrick to handle cargoes of pressure vessel plate and steam raising unit sections is almost ready, and a 150-ton luffing crane, the foundations for which have been built with the wharf, will be available to lift the heavier loads.

Before construction of the turbine house and cooling tower water system with its associated pumphouse and tunnels could be started, it was necessary to build a 2500 ft long seawall. This is now mainly completed and 70,000 sq yds of foreshore have been reclaimed. An 18 ft diameter access shaft for the tunnels was sunk down to 80 ft and preparations are under way for driving the access tunnel. A temporary dry dock in which the cooling water intake structure caisson will be built before floating to site is ready on the foreshore west of the main station. Extensive sea-bed surveys for the final positioning of the intake have been carried out this year. Rock excavation for the turbine house and associated cooling water culverts began in May and is now nearly half completed.



Pluto tank for Risö

After completing the road journey from Elsinore shipyard the 46-ton steel tank designed by Head Wrightson Processess for the Danish 10 MW PLUTO arrives at the reactor site at Risö

Belgian AEA to use a Mercury

Reactor calculations at the Belgian Atomic Energy Authority centre will be aided in future by a Ferranti *Mercury* high-speed electronic digital computer. A recent order makes the Belgian centre the seventh in Europe to standardize on this type, the others being at Geneva, Paris, Oslo, Stockholm, Harwell and Risley.

Priced at about £100,000, the *Mercury* was introduced twelve months ago, making a considerable advance in British-made computers specifically designed for large-scale scientific research. It is claimed that the large US computers cost nearly as much to hire for a year as it does to buy a *Mercury* outright.

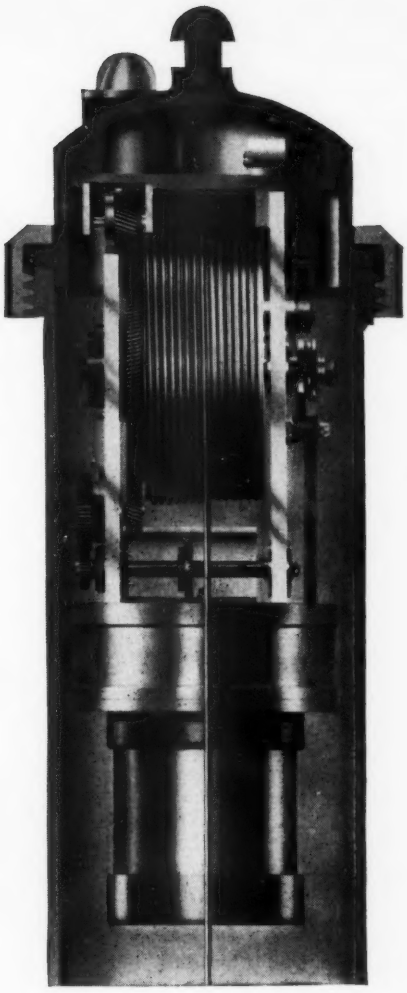
Activity mounts on Fermi plant

Among several mechanisms for the Enrico Fermi fast breeder plant which have been completed in General Electric of America's atomic power branch is a 34 ft high electronically controlled fuel handler. Designed to withstand the liquid sodium and operate inside the reactor enclosure at temperatures up to 1000°F, the 8-ton apparatus will replace fuel elements, breeder elements of depleted uranium, and control elements located in the 600-odd cells in the honeycomb shaped core.

When the controls—on a central panel in a separate building—are actuated, replacements will be fed to the manipulator

Precision Engineering for Nuclear Power Plants

Recognised for many years as one of Britain's leading precision engineering organisations, particularly for marine and aeronautical instrumentation and control, Sperry Gyroscope Company Limited is now offering its experience and extensive engineering and manufacturing facilities to designers and manufacturers of nuclear power plants. A qualified engineering team has been established to specialise in reactor control equipment and instrumentation.



A complete reactor control head mechanism designed by Sperry, with a number of special features to ensure safety, reliability and ease of operation and maintenance.

A Sperry servo-driven control rod position indicator, developed for the U.K.A.E.A.

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through an access chute into separate receptacles on a turntable. This will then revolve to place these elements within reach of the manipulator, and charging will be accomplished by closely controlled movement of the offset automatic manipulator across the face of the core to a selected square in the core honeycomb. Spent elements will be removed by placing them on the turntable and rotating them to the access chute where they will be mechanically lifted out of the reactor enclosure. In addition, the manipulator is linked with a reactor radiation monitoring system so that any unexpected increase in nuclear reactivity during core loading operations would automatically trigger the removal of key fuel elements to shut down the reactor.

Other parts due to be delivered by GE this year include the hold down device for keeping the reactor core in position. Constructed like an enormous press, it will withstand up to 130 tons to resist the hydraulic forces of the upward circulating sodium and the expansion resulting from the high operating temperatures.

Sylcor to make fuel charge

The initial fuel charge for the EFFBR is to be supplied by a private firm—the Sylvania-Corning Nuclear Corporation—it was announced recently. The $M1 order includes the 100 uranium core and 300 blanket sub-assemblies and the corporation says production will begin at once.

Steam plant ordered

The 91-ton steel reactor vessel is already on site and work will soon begin on the three steam generators and tube bundles, which are to be supplied by the Griscom-Russell company. Water flowing through the tube bundles inside the three steam generators will be heated from 380°F to steam at 780°F and 900 psi by liquid sodium at 820°F, falling to 520°F, circulated from intermediate heat exchangers. The resulting steam will be sold to Detroit Edison for use in producing electricity in a conventional turbine-generator plant next to the reactor building. The plant is scheduled to begin operating late in 1960 with an output of 100 MWe. Later, it is intended to produce enough steam to operate the turbine-generator at its full capacity of 150 MW.

Purifying argon at Dounreay

Further details of the argon purification plant under construction at Dounreay have been released by British Oxygen. The largest of its type to be operated by the Atomic Energy Authority, the unit will purify 3300 cu ft/h of argon and reduce the oxygen and nitrogen contents to less than 10 ppm and 40 ppm. It will operate for at least 1000 hours continuously, claims the company. Impure argon, at sub-atmospheric pressure and containing up to 0·2 pc by volume of air, leaves the AEA process and after admixture with electrolytic hydrogen is compressed to about 25 psig in a non-lubricated rotary compressor. It is then passed over a palladium catalyst where the oxygen impurity is converted to water. By means of a recycle circuit the hydrogen injection can be controlled to the stoichiometric requirements. The argon, now oxygen free, is dried by refrigeration in duplicate heat exchangers, cooled, liquefied and separated by distillation into pure argon and a nitrogen rich fraction which is rejected. In the process excess hydrogen is separated and is returned to the compressor suction. The purified argon passes back through the heat exchangers to the dry seal gasholder and thence to the AEA process.

Russians study UK techniques

A party of Russian engineers made a round of power stations and boiler manufacturing works recently to study British methods of steam raising and power generating. The group was headed by V. I. Baranov, deputy director of the department of Turbine and Boiler Construction, and a state planning committee

I. Petrov (left) from the Soviet State Planning Commission, examines a Unionmelt boom welding machine used on Berkeley boilers at John Thompson's Wolverhampton works. Accompanying him are director A. C. Coleman and J. H. N. Thompson, joint managing director

member. They included a visit to John Thompson's works and toured the specially equipped departments where parts for the Berkeley nuclear power station are being manufactured. Other techniques shown to the Russians included those employed in the manufacture of pipework, pressings for the motor industry, and water tube boilers. The tour was requested by the Russian trade delegation resident in London and later in the year the Water Tube Boilermakers' Association will send its own delegation to Russia.

EBR1 gets new core

Mark III core, designed to avoid thermal warping of the fuel elements, goes into the US EBR-1. Hopes are that new core will get over previous instability problems and allow study of safety aspects of fast breeders

New manipulators for Calder

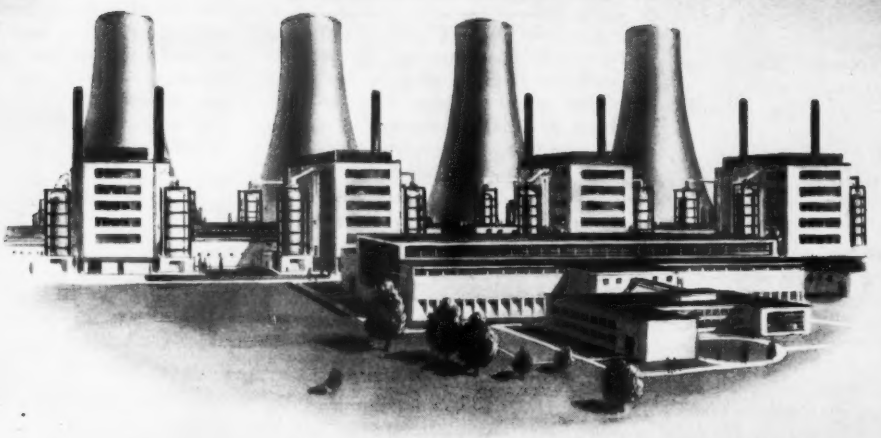
Two special power-operated manipulators for the continuous remote handling of spent fuel elements from the Calder Hall reactors have been designed and built by Savage & Parsons Ltd for the Industrial Branch of the United Kingdom Atomic Energy Authority at Risley. After being shown at the 'Atoms for Peace' Exhibition in Geneva the manipulators will be installed in the new pond now being built at Windscale. This is required to service all the spent fuel elements from both the existing and the new reactors on the nearby Calder Hall site, and the manipulators are designed specifically to transfer the elements from discharge baskets to skips—a continuous operation while reactor discharge is taking place. They will transfer the 24 elements from each basket, one at a time, and pack them into railborne skips which will then be submerged immediately in water for periods up to six months to allow the short-lived activity to decay. Each manipulator can handle up to 30,000 elements a year, the actual operation of transferring the contents of a basket to a skip taking approximately 30 minutes. As they will have come straight from inside the reactors, the fuel elements will be at a temperature of about 160°C as well as being highly radioactive.

Handlebar controls

The wall-mounted manipulator is a single vertical aluminium telescopic arm with shoulder, elbow and wrist movements, power-operated from a remote control unit. This is a gimbal-mounted box which has handlebars projecting 6 in. above the operator's desk top. Movements of the arm and jaws are ob-

CHAPELCROSS

ATOMIC POWER STATION TO BE LUBRICATED BY WAKEFIELD - DICK



The U.K. Atomic Energy Authority leads the world in the industrial application of atomic energy. To lubricate their new Atomic Power Station at Chapelcross they have chosen the lubrication specialists—Wakefield-Dick.

Wakefield-Dick have also been commissioned by the C.E.G.B. to supply lubricants to the Berkeley Nuclear Power Station.

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served through a zinc bromide window in the five foot thick shielding wall built round the pond, and the manipulator arm is moved away or towards the wall by pushing or pulling the control box; left and right movement of the forearm of the manipulator in the horizontal plane is obtained by pushing the control box sideways. The action is similar to that of an aircraft joystick, the operator merely pushing the control box in the required direction against the slight force exerted by the spring mountings. Independent vertical movement of the 'wrist' is obtained by rotation of the hand grips, and the jaws are opened and closed by a lever—similar to a motor cycle clutch—mounted on each of the grips which facilitates one-handed control. Telescoping of the arm is controlled by two foot pedals.

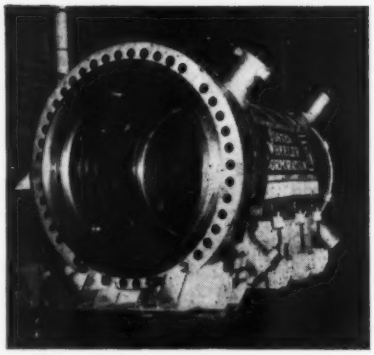
And a US-UK team up

News of Savage and Parsons' new manipulators coincides with an announcement that they are negotiating with a US firm for the establishment of a jointly-owned British-American company. This will be devoted to designing and marketing remotely-controlled handling equipment, and products will include mechanical and powered manipulators, reactor fuel loading and unloading systems, reactor maintenance systems, and other remote handling apparatus and ancillary protective equipment.

The US partner is the Mechanical Division of General Mills Inc, which has been designing and manufacturing heavy duty powered manipulators and reactor fuel charging systems since 1948. No announcement has been made regarding the name of the company, or definitely where it will be registered, although it is confidently expected to be in Great Britain. It is understood that the company will market the nuclear products of Savage & Parsons Ltd and General Mills Inc throughout the world.

Zirconium, titanium advances

High-purity, hafnium-free zirconium oxide and tetrachloride for nuclear and research applications are now available in tonnage quantities to users both in the US and other countries from the US Columbia National Corporation. Announcing this recently, the corporation added that availability of the chemicals would make possible the production of reactor-grade zirconium metal sponge and mill products by foreign companies having facilities for the production of titanium, zirconium, or other metals by Kroll-type processes. Pre-reduction operations to remove the neutron absorbing hafnium are performed at the Santa Rosa plant near Pensacola, Fla, using the *Nitrophos* extraction process.



A1W nears completion

The 100-ton PWR vessel of a land-based prototype for a naval surface ship is loaded on a railway car at the US Foster Wheeler Corporation. It is bound for the Idaho testing station

At about the same time as Columbia National's announcement, Metal Hydrides Incorporated offered a new grade of high purity zirconium hydride—MHI Grade R—which is reported to contain less than 0·01 pc hafnium.

Other news of nuclear metal developments in the US is the achievement of commercial production of high purity titanium metal by the National Research Corporation, which is partly owned by Columbia National. Figures of oxygen and carbon content quoted are 250 and 30 ppm for powder: 30 and 20 ppm for metal. The new process used results from a series of technological breakthroughs in the last two years, says the corporation. It is equally pleased with the development of a vacuum arc-welding furnace to convert the titanium powder to high-density ingots of 100 lb and more: hardness is said to be as low as 60—65 Brinell, allowing size reductions from 3 in. dia ingot to 0·005 in. foil without intermediate annealing. NRC titanium is now being bought by several AEC laboratories for research and development work in connexion with liquid metal cooled reactor programmes.

First fuel made for US Edison

Mass production of 488 fuel elements for the United States largest nuclear power plant, the 180 MW Dresden station near Chicago, began recently at General Electric of America's Atomic Power Equipment Department (APED), which is building the plant for the Commonwealth Edison Company and the Nuclear Power Group, Inc. Each of the 11 ft, rod-type assemblies will contain 144 smaller fuel rod segments containing pellets of sintered uranium dioxide, and when completed the reactor core will contain about 60 tons of uranium. The fuel will have an average life of about 3·5 years after the station goes into operation early in 1960.

As they are finished fuel elements will be stored in tubular drums at APED, then transferred to the permanent storage buildings in Dresden. Construction at the 1950-acre Dresden site is already well advanced, and equipment for the station is being moved into the 190 ft sphere, which houses the reactor, a steam separating drum, secondary steam generators, recirculating pumps and auxiliaries. The base is being prepared for the reactor vessel, and a turbine building, a fuel handling building, an administration and access control building and a shop and warehouse building are being constructed next to the huge sphere.

In brief

ZETA oscilloscope Cawkell Research & Electronics have received an order from the Max Planck Institut für Physik in Göttingen for a multi-channel oscilloscope similar to that made for measurements on ZETA. The company has now moved to Scotts Road, Southall, with telephone unchanged at SOUthall 3702/5881.

New particle accelerator A new machine known as the Tandem Van de Graaff has been built for Atomic Energy of Canada's Chalk River Laboratories by the US High Voltage Engineering Corporation; it is claimed to have accelerated protons to more than 13MeV and oxygen nuclei to over 30MeV with an energy precision of better than 0·1 pc.

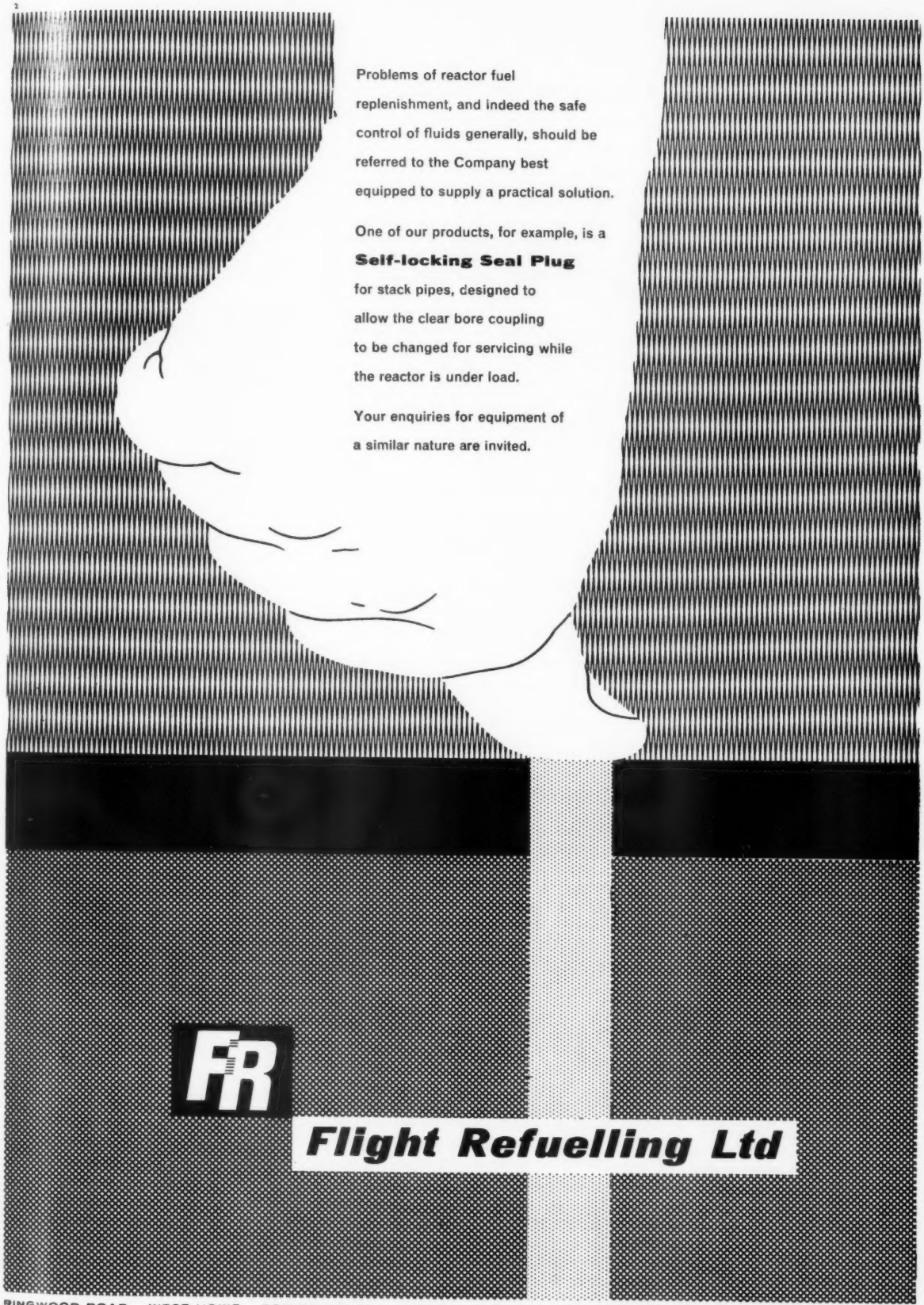
Italian subsidiary The US Vitro Corporation's activities in Italy will be conducted in future by a wholly owned subsidiary, Vitro Italiana, which was formed on August 12.

Incorporated Plant Engineers New head office opened on August 6 at 2 Grosvenor Gardens, SW1.

Radiographic inspection A new field and laboratory service for the examination of welds, casting and machine components has been established by Gammax Ltd, of London.

Helium A cheap method of separating helium from hydrogen by diffusing into tubes with thin glass walls has been developed at the US Bell Telephone Laboratories.

BNEC The British Nuclear Energy Conference has increased its membership to nine constituent bodies by the addition of the Joint Panel on Nuclear Marine Propulsion; this itself consists of four bodies—the Institute of Marine Engineers, the Institution of Naval Architects, the Institution of Engineers and Shipbuilders in Scotland and the North East Coast Institution of Engineers and Shipbuilders. BNEC will be represented at the Geneva conference by Sir Willis Jackson.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Potential reactor hazards

What can go wrong with an atomic power plant? Nuclear runaways, loss of coolant and breach of fission product containers are all possible hazards and a separate survey of these was made in a recent paper to the Comitato

J. L. GILLAMS
Cans may weaken

Nazionale per le Ricerche Nucleari in Rome. Authors were J. L. Gillams from the UK Atomic Energy Authority and A. G. M. Batten, assistant general manager of the Alliance Assurance Company.

Relays must not fail

A nuclear runaway could result from the insertion of excess fissionable material, a movement of part of the reflector, or some change in the operation of the reactor. In the case of a highly compact core like the fast reactor, there is even the risk that adjacent fuel elements will come too close together, with a consequent increase of reactivity. Protection against such events is provided by the fitting of relays for the immediate operation and control of safety rods: these are usually associated both with the rate of nuclear heating and with the coolant and moderator temperatures. 'It is clearly a common necessity to all reactors,' the paper stresses, 'that the relays do not fail, or that if they do, the reactor is automatically shut down.'

Several methods of control are in use, employing different mechanical systems, different absorbers, or the relative movement of moderator or fuel. Reactors also differ in the amount of space within the core which is available for control or safety rods, and in the amount of reactivity which has to be controlled—a more highly rated reactor suffers greater variations in fission-product poison, for example, and therefore needs a wider range of control. It follows that in small reactors of high-rating, greater reliance has to be placed on individual control rods. Rapid insertion into the core on emergency is then essential and it may be necessary to accelerate the gravitational fall of the rods by an ancillary mechanism.

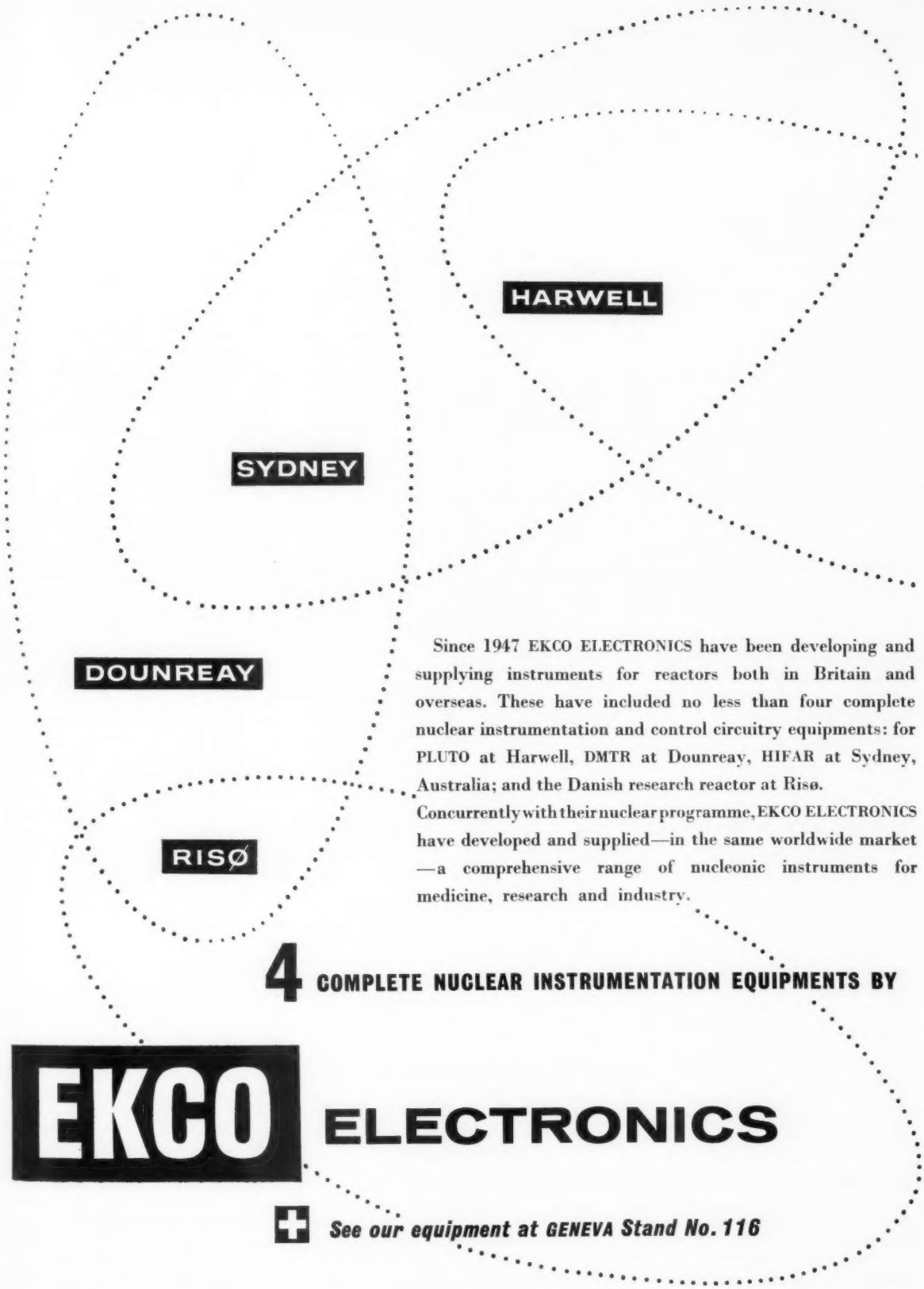
Quick-acting valves help

Some of the secondary effects of nuclear or non-nuclear overheating could also be caused by a loss of coolant. Whether from corrosion, brittle fracture, creep or even external causes, a hole or fracture might occur in the primary circuit, so that the coolant disappeared. In some reactors this can be overcome by good design; for example, quick-acting valves may seal off the affected part of the pressure circuit, so that most of the coolant is retained. If it is completely lost the residual activity of the decaying fission products within the burnt fuel creates a hazard in itself—the so-called 'after heat': this is proportional to the rate of heating immediately before shut-down, and in a highly rated reactor there might be only a few seconds before the fuel began to oxidize or melt. In gas-cooled reactors, especially, however, circulators can be given sufficient inertia to cover the time immediately following shut-down when the after heat is at its highest, and afterwards it can be controlled by natural convection. Coolant can also be effectively lost by a partial or complete failure of the circulators, and the paper emphasizes that adequate stand-by power supplies must be available for this, and other, essential purposes. Some reactors are designed so that loss of coolant is never important; e.g. a reactor may be sited in a completely leak-proof pit which is already full of water.

Except in reactors like the homogeneous aqueous type in which most or all of the fission-products are deliberately permitted to enter the cooling circuit, the primary containment of fission products lies in the sheath of the fuel element. This will normally be designed with enough strength to stand the maximum expected burnup but, particularly near the end of the fuel element's lifetime, consider the authors, the can may be liable to weakness. In the event of a widespread failure the activity released into the primary circuit would, of course, be very appreciable and might require major work on the reactor system; for instance, the contamination might prevent inspection or maintenance of heat exchangers or circulators. Even if the fuel element cans had failed, however, the activity would still be confined within the primary circuit, but the possibility remains that it might escape through safety valves, and it is 'a matter of importance' that these should either be adequately contained, or should be fitted with filters which would stop both gaseous and particulate fission products, and operate under both normal and abnormal conditions. Some reactors have a further degree of containment in the form of an overall pressure-tight building, and it is then necessary to ensure that doors or ventilators are suitably controlled, possibly even by reactor fuel temperature trips.

A. G. M. BATTEN
No system is foolproof

'To these risks,' conclude the authors, 'must be added the hazard of operational negligence in which the system, though of an almost fool-proof technical design, fails because of persistent mistreatment; e.g. the failure of fuel elements due to unnecessary and too rapid thermal cycling; the failure of control-rod mechanisms because of lack of care in maintenance; the failure to control water purities at levels inhibiting corrosion: and the misuse of experimental channels within the reactor to give an unexpected increase of reactivity.'



Since 1947 EKCO ELECTRONICS have been developing and supplying instruments for reactors both in Britain and overseas. These have included no less than four complete nuclear instrumentation and control circuitry equipments: for PLUTO at Harwell, DMTR at Dounreay, HIFAR at Sydney, Australia; and the Danish research reactor at Risø.

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Book Reviews

Engineering

Nuclear Reactor Experiments Edited by J. Barton Hoag. London, 1958: D. Van Nostrand. 480 pp. Price 51s.

Incredible though it sounds, this book has forty-four authors, one for about every ten pages. It is, of course, really a collection of separate articles and each is written by one or more experts from the Argonne National Laboratory. Even with all his experience, the editor, J. B. Hoag, must have found his task a rather trying one. To avoid unnecessary repitition and yet ensure adequate cross-references is almost impossible, one would think, with a team of this size, and a number of both types of fault are apparent; references are sometimes made not to the appropriate article in the volume, but to entirely separate sources. These are, however, matters of detail and one should look also at the broader features: what is the form of the book and for whom is it intended?

The first impression is that it describes most of the equipment in the Argonne Laboratory and certainly £M1 would not cover the capital involved, even neglecting the CP5 reactor. For the staffs of our universities and colleges, then, one value of the book could well be as a present for the University Grants Committee and other similar bodies. It is not selective enough to be really helpful in the detailed planning of training courses, although a copy on the laboratory bookshelf would be useful as a reference for technical details.

For students the main value is the demonstration of the wide range of subjects covered by nuclear engineering; metallurgy, chemistry, engineering are there as well as nuclear and reactor physics. However, most of the articles are not very good examples of laboratory manuals: far too much instructional detail is given to the extent of specimen calculations and data sheets.

The format of this book is very pleasing, the standard of diagrams is high and there is a generous allowance of photographs.

J. Walker

Radiochemistry

The Chemistry of the Rare Radioelements K. W. Bagnall. London, 1957: Butterworth Scientific Publications. 177 pp. Price 30s.

It is always a pleasure to read a well written book by one whose experimental investigations entitle him to claim authority in the field he covers. More than half this short monograph, which covers the elements from polonium to actinium, is devoted to the chemistry of polonium, a field in which the author has made very substantial contributions. The account of the chemistry of this previously little known element is without equal. It includes a brief but valuable description of the very specialized techniques necessary for the handling of such highly alpha-active substances—a problem of growing importance in many laboratories. The bibliography of polonium and the other elements includes all the really useful papers pertaining to their chemistry.

The somewhat imperfectly known chemistries of astatine, francium and radon are collected into one short chapter—this would, perhaps, repay revision. For instance the chemical identification of the natural astatine, formed by the alpha decay of actinium K (Fr-223) is omitted, but the much more doubtful beta branching of AcA, and especially ThA, is not questioned.

The last chapter deals with the chemistry of actinium and radium, providing an especially useful account of the recent work on the former element. An interesting reflexion on this chapter is the observation that radium is rapidly becoming one of the least extensively investigated heavy elements.

The book is agreeably produced and free from irritating typographical errors.

A. G. Maddock

Metallurgy

Effect of Surface on the Behaviour of Metals London 1958: Iliffe for the Institution of Metallurgists. 100 pp + 10 pp plates Price 21s

Since 1947 the Institution of Metallurgists has held an annual refresher course for its members, each year a particular theme being chosen. The 1957 course was focused on surface effects and this volume includes the papers read during the course.

The first paper, by Dr G. L. J. Bailey, deals with the preparation of surfaces for examination, and discusses modern methods of examining the topography and structure of surfaces, the latter both on the microscopic and atomic scales. This is followed by a paper by Dr T. P. Hoar, which shows how the treatment that a surface has received has a bearing on its future chemical behaviour. Dr F. T. Barwell then summarizes the present state of knowledge on the relationship between surface condition, frictional resistance and wear.

Finally, Dr R. W. B. Stephens deals comprehensively with the influence of the surface on the physical properties of a metal. After explaining why the surface of a metal should exhibit different effects to the interior, he deals with such things as optical properties; skin effect; moiré fringe patterns in electron micrographs; electrical resistance; thermal properties; catalysts; magnetic properties; the domain theory; thermomagnetic and galvanometric effects; and diffusion.

Organization

Euratom: Analyse et Commentaires du Traité by J. Errera, E. Symon, J. van der Meulin and L. Vernaeve 436 pp Brussels 1958: Editions de la Librairie Encyclopédique SPRL. Price 425 francs (Belgian).

The Euratom treaty has both a juridical and technical character which is not easy to understand. Written at the instigation of the Belgian Institute of Political Science by a group of experts, the volume provides a useful guide to the ramifications of the treaty which came into force on January 1 this year.

After an introduction which discusses the treaty in relation to the European Community idea, the book then analyses systematically its clauses, illustrating the treatment with comparisons between Euratom and the Coal and Steel Treaty. A complete text of the Euratom Treaty is included and a comprehensive index provides a most useful guide to this complex document.

Reference

Communications and Electronics Buyer's Guide, Who's Who and Reference Book Ed. C. C. Gee London 1957: Heywood & Co. Price £5 5s

Running to over 500 pages this new reference book is claimed to be the first objective and comprehensive guide to the British electronics industry. It lists firms under product classifications and addresses, includes a Who's Who section remarkable more for the number of entries than the amount on each person, and a useful reference section in which surveys are made of selected commercially available components. It also includes details of educational establishments, industry statistics, summaries of British Standards, colour codes etc.

L'ATOME POUR LA PAIX

ELLIOTT POUR L'AUTOMATION

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NAMES IN THE NEWS

Mr P. S. Beale, former chief cashier, Bank of England, has been appointed a director of The British Oxygen Co Ltd.

Mr R. J. Barritt commences duties on September 1 as chief executive of British Oxygen's Engineering Division.

New director of Plessey International Ltd is **Mr P. W. Faulkner,** who has been with Plessey since 1952. Mr Faulkner will remain a director of The Plessey Co and Technical Ceramics Ltd.

Roballo Engineering Co Ltd, a newly formed company to market and eventually manufacture Roballo slewing rings in this country, has appointed **Mr H. L. Lloyd** to be general manager.

Dr J. B. Higham has been appointed to the new post of head of technical development at Pilkington Brothers Ltd, the glass manufacturers.

EMI Electronics Ltd have made **Mr K. Elphinstone** their new export manager, following **Mr R. W. Addie's** recent election to the board as marketing director.

Stanton Instrument representative for Scotland and parts of Northern England will be **Mr Owen Brooks** who joined the firm earlier this year.

Mr E. F. Dunkin has been appointed UK Sales Engineers for Venner Electronics Ltd. He will be responsible for technical liaison and sales promotion.

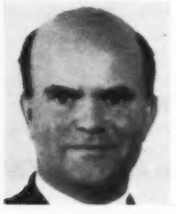
Two new appointments are announced in the cable divisions of Siemens Edison Swan Ltd. **Mr R. G. Holland** will be assistant cable sales manager, special contracts, and **Mr R. B. Tucker** becomes assistant sales manager, rubber and plastic cable division.

British Oxygen Company executive director **Mr J. Strong** has been elected president of the Institute of Welding 1958/9. He succeeds **Sir Charles Lillicrap.**

LORD HALSBURY

A. F. STREET

T. GIUSTI



K. ELPHINSTONE

Mr A. W. A. Dick-Cleland has relinquished his directorships of Lancashire Dynamo Holdings and Lancashire Dynamo Crypto.

As from October 1 **Mr P. D. Proctor,** at present a deputy secretary in the Ministry of Transport and Civil Aviation, will be permanent secretary to the Ministry of Power.

Joint managing director of Plessair Ltd, **Mr V. A. Kennett** has now returned from a visit to Russia where he had talks with the director of the electronics section of Technopromiport, a department dealing with communications.

Mr George Millington, chief of propagation section at Marconi's Wireless Telegraph Co, is chairman-elect of the radio and telecommunications section committee of the Institution of Electrical Engineers for the coming year.

Mr A. F. Street has been appointed a director and chairman of The Micanite & Insulators Co Ltd. Mr Street is director of several companies in the AEI Group.

Managing Director of the National Research Development Corporation, the **Earl of Halsbury** will retire in March 1959.

Mr. H. G. Bell has been appointed consulting engineer, instrument meter department of Metropolitan-Vickers Electrical Co Ltd. This follows his recent retirement as chief engineer of the North Western Electricity Board.

OBITUARY

The death occurred on July 23 of **Mr Tito Giusti,** a naval architect who in 1918 founded the chemical plant manufacturing firm of T. Giusti and Sons Ltd. Mr Giusti was 86.

CATALOGUES AND BULLETINS

Panel instruments for many purposes are described in catalogue from Ferranti Ltd. The firm have also published the second edition of a publication on the Pegasus computer containing detailed description and instructions.
Tick **No 208** on reply card

Midland Silicones Ltd, a member of the Albright & Wilson group, has particular prominence given to its activities in a new brochure brought out by Albrights.
Tick **No 209** on reply card

Booklet describing the **aims and objects** of the British Chemical Plant Manufacturers Association is now available free to interested firms.
Tick **No 210** on reply card

Analmatic **auto-titration** equipment which can be supplied suitable for operation in corrosive or hazardous atmospheres is fully described in publication from Baird & Tatlock (London) Ltd.
Tick **No 211** on reply card

Monograph No 35 (1958) from Hopkin & Williams Ltd entitled **2·4-Xylenol** (reagent for nitrate) by J. T. Yardley and T. H. Cooper has been published.
Tick **No 212** on reply card

Colour folder from Morgan Crucible describes electric **furnace elements** made of *Crusilite* a new non-metallic material. Model DS in this range has both electrical connexions at the same end.
Tick **No 213** on reply card

Hoists and rams and balance-opposed compressors are fully described and illustrated in two catalogues from Consolidated Pneumatic Tool Co Ltd.
Tick **No 214** on reply card

Sea Highway is the title of an attractive booklet issued by Head Wrightson & Co Ltd to commemorate the transport by sea of heat exchangers supplied to Bradwell.
Tick **No 215** on reply card

Informative and well illustrated booklet from Film Cooling Towers gives photographic examples of the industries in which various types of cooling towers are used.
Tick **No 216** on reply card

Stock lists of lead coated **steel sheet** 'seconds' are issued from time to time by Richard Thomas & Baldwins (Sales) Ltd.
Tick **No 217** on reply card

Of particular interest in a new range of **miniature relays** listed by Londex Ltd are types LOK, a totally-enclosed plug, and SMM which uses a microswitch as the switching medium.
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RITCHIE CALDER'S *Signposts to the Atomic Age*

ATOMIC HEAT to freeze the Arctic...

"IN THE FROZEN WASTELANDS OF THE Canadian North, Eskimos and Indians, going off to hunt the caribou or trap for furs, are taught how to prospect for the fuels and metals of The Atomic Age. They are part of that Age and very much aware of it. *Innuit*, the Eskimo of the Barrens, no longer laughs at the eccentric interest which *Kabloona*, the White Man, shows in yellow-stained rocks; he knows what makes a Geiger-counter tick and recognises uranium when he sees it. His Tree-line neighbour, the Cree Indian 'brave' has already grasped the meaning of atomic energy—he calls it *Eskoitik-otchi-Kaochipyik* which is 'Lightning-which-comes-out-of-Rock'.

Those vast empty spaces, half the size of the United States, are already being systematically surveyed. Geologists, on the ground and from the air, are charting its fabulous mineral wealth. Helicopters, fitted with gravimeters, magnetometers, and scintillometers, can detect the ore-bearing deposits beneath the snow and ice, the pathless forests and the countless lakes. Their charts already speak eloquently of the abundance of the

atomic fuels and "new" metals for which the metallurgists and nuclear engineers are praying; but most of that wealth is locked up in remote parts of the Pre-Cambrian, or Laurentian Shield, so inaccessible to conventional haulage, by road or rail, as to seem unworkable.

Yet the answer could lie in atomic energy itself.

Imagine 'industrial oases', powered and heated by "packaged reactors" and reached only by aircraft. The reactors themselves could be assembled by air-supply (which has already served in the construction of the massive defence installations in the Canadian Arctic). Once the reactors are established and 'critical', fuel-replenishment would be no problem.

Completely civilised townships could be created with adequate heat to counteract the climate, and modern amenities to enliven the Long Night. Again the prototype exists in the Canadian base at Churchill on Hudson Bay and the U.S. base at Thule, in Greenland. With self-sufficient power, independent of coal-trucks, oil-tankers, or pipe-lines, the ores could be mined, milled and processed into small bulk and flown out by air, like the casks of sodium uraninate from the Eldorado mine on Lake Athabasca.

That raises another problem for which atomic energy could have a quaint answer. How to ensure all-the-year-round air-communications? The winter, contrary to popular belief, is the best time; the sea and lake ice can take the heaviest aircraft. The trouble starts with the coming of the sun. Ice thaws. Airstrips heave and toss and melt into mud, while the permafrost, the continuously frozen sub-soil and rocks, remains solid underneath. With sufficient power available, the airstrips and roads could be refrigerated and kept solid, like an ice-skating rink.

Atomic heat to freeze the Arctic! It is like selling refrigerators to the Eskimos." [R.C.]

* * *

MITCHELL ENGINEERING *are designing and constructing Nuclear Power Plant to meet world needs in the New Atomic Age.*

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Research Reports

The following reports have been made available to the public by the United Kingdom Atomic Energy Authority. They may be borrowed or photocopies obtained from the Science Library, London, Department of Industrial and Forensic Science, Belfast, the Mitchell Library, Glasgow, and the Central Libraries at Acton, Birmingham, Bristol, Kingston-upon-Hull, Leeds, Liverpool, Manchester, Newcastle-upon-Tyne and Sheffield. They are also deposited in the Copyright Libraries (i.e. British Museum; University Library, Cambridge; Radcliffe Science Library, Oxford; National Library of Scotland, Edinburgh; National Library of Wales, Aberystwyth) and in the Patent Office Library. Reports marked may be purchased from Her Majesty's Stationery Office.*

Reports are also available in the United States, from the USAEC depository libraries, a list of which will be found in NUCLEAR SCIENCE ABSTRACTS. Reports for sale may be purchased in the United States from: Sales Section, British Information Services, 30 Rockefeller Plaza, New York 20, N.Y.

AERE Harwell

Calculation of the neutron migration length in an infinite lattice. *D. J. Behrens.* (June 1948. 15 pp) AERE T/R 221 2s 6d*

The microstructure of graphite. *L. E. J. Roberts, E. A. Harper, C. T. Small.* (May 1952. 33 pp) AERE C/R 882 4s 6d*

Critical assemblies of aqueous uranyl fluoride solutions. Part 2. Preparation and handling of solutions. *J. E. Cunningham, G. P. Wall, I. Wells.* (April 1958. 28 pp) AERE CE/R 2052 6s*

An experimental study of the slowing down of fission neutrons and the diffusion of thermal neutrons in graphite and in heterogeneous mixtures of bismuth and graphite. *W. G. Davey, J. C. Field, J. C. Gilbert, A. L. Pope.* (March 1958. 79 pp) AERE R/R 2501 13s*

Hydromagnetic instabilities of a cylindrical gas discharge. Part 6. Energy principle calculations for axisymmetric perturbations. *M. H. Boon, et al.* (March 1958. 38 pp) AERE T/R 2503 6s*

Effects of heat and pressure on the swelling of irradiated uranium. *A. T. Churchman, R. S. Barnes, A. H. Cottrell.* (March 1958. 16 pp) AERE M/R 2510

Thermal conductivity of UO_2. *R. Scott.* (March 1958. 16 pp) AERE M/R 2526

The analysis of thorium-magnesium binary alloys. *G. W. C. Milner, J. W. Edwards.* (April 1958. 6 pp) AERE C/R 2537 1s 9d*

A study of single-zone U-233 thoria slurry reactors. *W. G. Clarke.* (April 1958. 20 pp) AERE R/R 2537 3s*

Radioactive and natural strontium in human bone. UK results for 1957. *F. J. Bryant, et al.* (May 1958. 11 pp) AERE C/R 2583 2s 6d*

A siphon starting device. *H. W. Marsdon.* (Dec 11, 1952. 6 pp) AERE E/M 65 1s 9d*

A plating bath for polonium. *P. J. Gomm.* (April 1958. 5 pp) AERE Med/M 22

Industrial Group

The analysis of sodium metal and sodium-potassium alloy: collected Capenhurst methods. (March 1958. 83 pp) IGO AM/CA 110

Argon isotope analysis with an M.S.3 mass spectrometer using the double-collection technique. *P. G. Bentley, A. N. Hamer.* (1958. 5 pp) IGR TN/CA 851

Non equilibrium beta retention in fuel elements. *R. B. Kehoe.* IGR TN/C 855

Canada

The following reports may be obtained from: Scientific Document Distribution Office, Atomic Energy of Canada Ltd, Chalk River, Ontario. Remittances should accompany the order and should be in the form of cash, bank or express postal money orders or cheques made payable in Canadian funds at par in Chalk River to Atomic Energy of Canada Ltd. Copies of Canadian research reports are held at the United Kingdom Atomic Energy Authority's depository libraries.

Ion-chamber data. *H. Carmichael.* (1945. 19 pp) AECL 290 MTec-168 50c.

Experimental determination of stored energy in graphite irradiated with neutrons. *R. W. Attree, R. L. Cushing, J. Pieroni.* (1957. 26 pp) AECL 442 CRC 693 $1.00

The preparation of plutonium-aluminium alloys. *O. J. C. Runnalls.* (1953. 16 pp) AECL 458 50c.

Neutron capture by long cylindrical bodies surrounded by predominantly scattering media. *S. A. Kushneriuk.* (1957. 61 pp) AECL 462 CRT 712 $1.50

The quantum theory of angular momentum. *W. T. Sharp.* (1957. 81 pp) AECL 465 CRL 43 $2.00

The determination of trace quantities of uranium in NRU aluminium sheathing by neutron activation analysis. *W. D. MacKintosh.* (1957. 22 pp) AECL 481 CRDC 704 50c.

Oxidation of Pu (IV) to Pu (VI) in solutions of nitric acid, aluminium nitrate, sodium nitrate and uranyl nitrate. *I. H. Crocker.* (1957. 54 pp) AECL 488 CRDC 697 $1.50

The spherical harmonics method II. *C. Mark.* (1957. 96 pp) AECL 490 CRT 338 $2.00

The spherical harmonics method I. *C. Mark.* (1957. 45 pp) AECL 491 CRT 340 $1.00

NRU thermal power control. *A. Pearson, C. G. Lennox.* (1957. 53 pp) AECL 506 CREL 737 $1.50

The NRU reactor—lectures given at Chalk River, Ontario, Feb-April 1956. *M. D. Ferrier.* (1957. 242 pp) AECL 507 CRE 681 $4.00

The processing of irradiated thorium fuels using tributyl phosphate-decalin. *W. W. Morgan.* (1955. 28 pp) AECL 508 CRDC 674 50c.

Cross-sections of Pu 239 and Pu 240 in the thermal and epicadmium regions. *F. W. Cornish, M. Lounsbury.* (1956. 39 pp) AECL 510 CRC 633 $1.00

Two-group two-dimensional flux distributions for several PTR loadings. *R. M. Pearce.* (1957. 30 pp) AECL 512 CRRP 728 $1.00

Aluminium sheathing of flat uranium plates by extrusion cladding. *A. J. Mooradian.* (1957. 42 pp) AECL 513 CRL 46 $1.00

The preparation and sheathing of plutonium-aluminium fuel alloys for the NRX reactor. *O. J. C. Runnalls, K. L. Wauchope.* (1957. 14 pp) AECL 514 CRL 47 50c.

The production of UO_2 for ceramic fuels. *L. C. Watson.* (1957. 27 pp) AECL 515 CRL 45 $1.00

Progress report—physics division July 1, 1957, to September 30, 1957. *J. M. Robson.* (1957. 68 pp) AECL 517 PR-P 35 $1.50

Transistorized radiation monitors. *F. S. Goulding.* (1957. 17 pp) AECL 518 CRE 701 $1.00

Extrusion cladding of NRU fuel element. *H. S. Milne.* (1957. 35 pp) AECL 519 CRE 701 $1.00

The development of bonded fuel elements by the process of extrusion cladding. *G. V. Kidson.* (1957. 25 pp) AECL 520 CRMet 703 $1.00

Transistor noise in nucleonic instruments. *A. R. Jones.* (1957. 19 pp) AECL 524 CREL 734 50c.

The NRU reactor. *G. C. Laurence.* (1957. 19 pp) AEOL 525 CRL 49 $1.00

SEPTEMBER DIARY

MONDAY 1-SUNDAY 14
GENEVA United Nations Second International Conference on the Peaceful Uses of Atomic Energy, Palais des Nations

GENEVA Atoms for Peace Commercial Exhibition, Palais des Expositions

SUNDAY 7-THURSDAY 11
MONTREAL World Power Conference, Canadian sectional meeting

TUESDAY 16-SATURDAY 20
PARIS Electronics in nuclear energy symposium. Unesco House, Place de Fontenoy, Paris

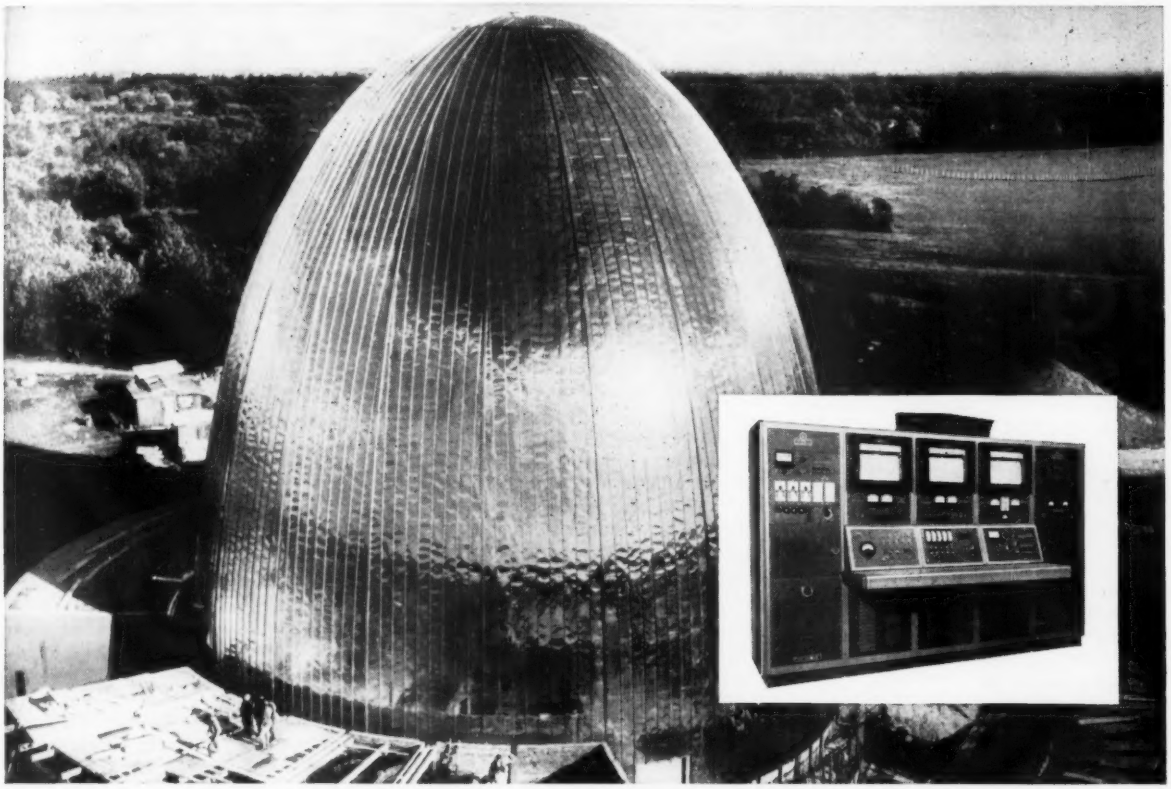
THURSDAY 18
BLACKBURN IPE Recent advances towards thermonuclear power (SCEPTRE and ZETA). *J. E. Read.* 7.30 at the White Bull Hotel

MONDAY 22
VIENNA Second session of the general conference of the International Atomic Energy Agency opens

WEDNESDAY 24-FRIDAY OCTOBER 3
LONDON Industrial fuel efficiency exhibition. Nuclear energy papers will be read at Institute of Fuels technical meetings on September 25. National Hall, Olympia

Peaceful nuclear landmark: Rising 100 feet from the flat farmlands near Munich, Germany, is this aluminum-sheathed nuclear reactor, main laboratory instrument of the nuclear research centre at Munich Technical University. Designed and built by AMF, the 1,000 kilowatt pool-type research reactor is the first to become operative in Europe under President Eisenhower's "Atoms for Peace" programme.

(Inset) The control console of the AMF-built Munich Research Reactor. The reactor will be used to train students in nuclear research, primarily in the field of solid state physics. It will also produce radioisotopes for use in medical and industrial research, as well as for use by the University itself and other educational centres.



FIRST AMONG RESEARCH REACTOR BUILDERS–

AMF creates new tool for atomic probe!

With the opening of Munich Technical University's new atomic research centre, AMF—the leader among research and training reactor builders—now has three installations in operation, with twelve more in various stages of design and construction. In fact, *AMF is today building more than twice as many research and training reactors* as any other company in the world!*

In the field of atomic power, AMF Atomics works in close cooperation with Dr. Walter H. Zinn and his General Nuclear Engineering Corporation, as well as with Mitchell Engineering Ltd. of London. Together they have developed a number of advanced power reactor designs which offer great promise for the economic production of electricity in areas in which conventional fuel costs are high.

Ship propulsion is a particular application of nuclear energy in which AMF has specialized experience. Under a Nuclear Energy Programme sponsored by a joint committee of the U.S. Maritime Administration and the U.S. Atomic Energy Commission, AMF recently designed a Closed Cycle Boiling Water Reactor System for propulsion of a 38,000-ton tanker. The AMF design was approved by the joint committee and has now become the basis for a construction programme.

Dockside refueling of a nuclear-powered vessel presented a knotty problem which AMF successfully solved. For example, the complete refueling of the nuclear submarine, "Seawolf," is handled by such AMF equipment.

Eminently qualified in all aspects of nuclear ship propulsion, AMF is prepared to conduct feasibility studies, design power plants, manufacture all or part of the components, furnish consulting and engineering services, as well as supervision during installation, loading of fuel and sea trials.

In addition to their reactor design and construction activities, AMF Atomics has also taken the lead in the development of reactor control-rod drives, remote material handling equipment and other specialized nuclear components. Such AMF equipment is now in service throughout the world.

For a complete reactor facility, either for training, research, power or ship propulsion ... for specialized control and handling equipment ... for authoritative assistance at any stage of *your* atomic energy programme ... AMF nuclear design and development engineers will be glad to work with you on your specific problems.

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Visit AMF's Stand No. 4Y at the Second International Exhibit of Peaceful Uses of Atomic Energy in the Grand Palais des Expositions, Geneva, September 1-14, 1958.

Tick **No 90** on reply card for further details

NEW IDEAS
nucleonic patents

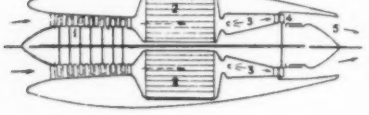
Borated graphite shield

Morgan Crucible made the neutron shield for the Dounreay Fast Reactor, and this method of making borated carbon blocks is probably how it was done. Anhydrous borax is the best compound because it has a low melting point—650° to 750°—and can be melted in the block during manufacture. Also it flows into the graphite pores to produce a strong bond, so that less binder has to be used than usual in making graphite blocks. The graphite must be substantially free from harmful contaminants such as cobalt or zinc, which become radioactive, or the toxic halogens. The graphitic mix is made into blocks—suitable size 2 ft 6 in. by 9 in. by 9 in.—by consolidating it in increments in a mould with a pneumatic hammer and then heat treating it at about 1000°C to melt the boron. The proportion of boron varies according to the neutron absorption required but generally ¼ pc or more by weight provides effective neutron shielding.

797,692 Shields for nuclear reactors *The Morgan Crucible Co Ltd* (inventor: I. J. Lockyer) Appn: Aug 12, 1955 Pubd: July 9, 1958

Nuclear airplane

The shielding problem in nuclear-powered aircraft is twofold—protection of the crew, and of people in the nearby region. This patent aims to dispense with the latter by providing the aircraft with a conventional jet propulsion unit for use during take-off, landing and



798,617 REACTOR OR TURBOJET

1 Axial-flow compressor
2 Nuclear reactor
3 Combustion chambers
4 Turbine
5 Ejection nozzle

low altitude flight, combined with a reactor for use at high altitudes. The propulsion unit comprises a multi-stage, axial-flow compressor delivering air through the channels of a reactor, a number of combustion chambers, and the nozzles and rotor blades of a turbine, finally discharging it through an ejection nozzle. When the aircraft is on or near the ground the reactor is shut down, the air passes through it without heating and the combustion chambers are fed with hydrocarbon fuel so that the unit becomes a conventional turbojet. There is a pressure loss between the compressor and combustion chambers prevented by a modification of the idea in which these units are parallel.

798,617 Improvement in aircraft propulsion *Societé Rateau and René Anxionnaz* Appn: Nov 23, 1955 Pubd: July 23, 1958

Built-in control

To keep the value of k virtually constant over a long period of time without changing the reactor controls, GEC of America propose a fuel element with neutron capturing characteristics which change at a constant rate. It consists of U-235 alloyed with either aluminium or zirconium and containing a fine, even dispersion of boron-10. As the reaction proceeds, the boron ($\sigma = 3990$ barns) is gradually transmitted to lithium-7 ($\sigma =$ 33 millibarns) at a rate proportional to the fission process. Thus, as the uranium is consumed, the number of neutrons removed from the reaction is proportionally reduced.

Suitable proportions for the alloy are 15 to 23 pc by weight uranium, 0·1 to 0·5 natural boron (which contains 18·8 pc B-10) and the balance aluminium or zirconium.

796,989 Improvements relating to neutronic reactor fuels *General Electric Company (USA)* Appn: Feb 6, 1956 (in USA) Pubd: June 25, 1958

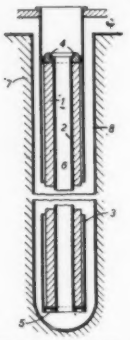
Common pressure

In this heavy-water reactor operating at about 130°C, both moderator and coolant are under the same pressure. The aluminium reactor vessel cannot be made sufficiently thick to withstand the pressure required to prevent boiling and consequently is surrounded by a steel pressure vessel which can withstand 7 atmospheres. The interspace is filled with a reflector—either graphite or heavy water. The reactor vessel cover is the collecting vessel for the heavy water which is sucked through tubes in which the fuel rods are suspended, through the heat exchangers and back to the reactor vessel. The tubes are attached to the bottom of the collecting vessel, the fuel rods to its cover with which they can be removed as a composite unit.

797,485 Improvements in low temperature reactors *Allmanna Svenska Elektriska Aktiebolaget.* Appn: Nov 24, 1955 Pubd: July 2, 1958

SGR fuel element

One of the factors limiting fuel element temperature is the creep strength of the sheath material. Designed for a graphite-moderated, sodium-cooled reactor, this arrangement ensures that the part of



798,282 TAKING THE WEIGHT

1 Uranium fuel
2 Inner zirconium sheath
3 Outer zirconium sheath
4 Flexible end cap
5 Rigid end cap
6 Channel
7 Graphite
8 Zirconium lining

the sheath supporting the weight of the cartridge is kept cool. The fuel element is cylindrical, enclosed in zirconium sheaths, the inner one, 2, being pressurized tight on to uranium and the outer, 3, spaced from it at a uniform 0·1 in. insulating gap, filled either with air or solid insulator such as magnesia. The outer sheath carries the weight of the element via the rigid end cap 5. The channel, 9, has a zirconium lining which encloses all the graphite. Incoming sodium flows downwards round the element keeping the outer sheath moderately cool, and up through the inner sheath where most of the heat transfer takes place.

798,282 Improvements in or relating to fuel element for nuclear reactors. *United Kingdom Atomic Energy Authority* (inventor: G. D. Bell) Appn: April 19, 1956 Pubd: July 16, 1958

In brief

UKAEA's no 798,441 describes a heat transfer system for a **fluidized bed** by injecting into it a liquid which flash evaporates to a vapour at the operating temperature, thus fluidizing the bed.

To allow easy removal from the core, C. A. Parsons suggest **absorber rods** in articulated or link form in 798,466. The links may have varying degrees of neutron absorbing capacity.

A method of producing a **tubular U-235 fuel element** sheathed in beryllium is detailed in 798,434, a UKAEA specification, using a die in which the beryllium powder is compacted, followed by sintering at 800°C.

These abstracts are made from British Patent Specifications with the permission of the Controller of Her Majesty's Stationery Office. Complete specifications can be obtained from the Patent Office (Sales Branch), 25 Southampton Street, London, W.C.2. 3/6 a copy (including postage, inland and abroad)

PAGE(S) MISSING

KIDDE

on guard at

Chapelcross

Fire Precautions in the Turbine Hall
and Reactor Buildings 1, 2, 3, and 4 are entrusted
to Kidde. The safety of
personnel and the protection
of vital equipment are
ensured by the installation
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CASTINGS

IN STAINLESS, SPECIAL ALLOY AND CARBON STEELS FOR BRITAIN'S NUCLEAR POWER STATIONS

Reactor Guide Pan Casting in BS 592B steel, as supplied for the Hunterston Nuclear Power Station of the South of Scotland Electricity Board to the order of the General Electric Co. Ltd., of England.

The commercial application of nuclear energy has demanded increasingly exacting material standards—not least in cast steel reactor components.

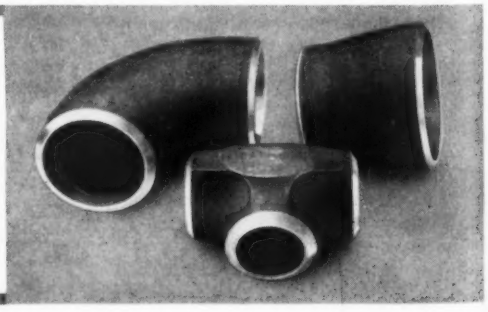
A.P.V.-Paramount, by their advanced foundry techniques, are already providing a high proportion of the stainless, special alloy and carbon steel castings for the nuclear plants.

STAND No. 144

"ATOMS for PEACE" EXHIBITION

GENEVA SEPT. 1st — 14th

. . . and now a range of
PARALLOY
"FORGING QUALITY"
CAST STAINLESS STEEL
PIPE FITTINGS
Details on application



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Boiler Feeding

in the new

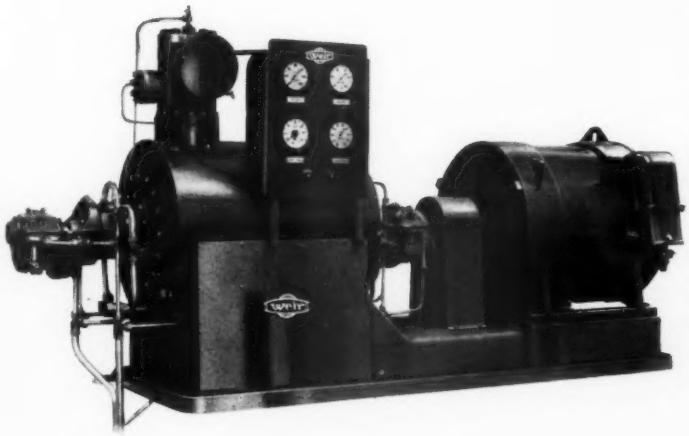
Nuclear Power Stations

3 **of the four stations now being built in the United Kingdom**

will be completely equipped with

Weir ELECTROFEEDERS

This is only a part of the major feed pump work in hand for the electricity supply industry in this country and overseas, for nuclear and conventional fuel stations.



HINKLEY POINT

Ten Weir Electrofeeders are being supplied to the order of The English Electric Co. Ltd.

HUNTERSTON

Twenty Weir Electrofeeders will be supplied to the order of Simon-Carves Ltd. for the high and low-pressure circuits in the steam raising units at Hunterston.

BERKELEY

Eight Weir Electrofeeders have been ordered by John Thompson (Water Tube Boilers) Ltd., for the Berkeley nuclear power station.

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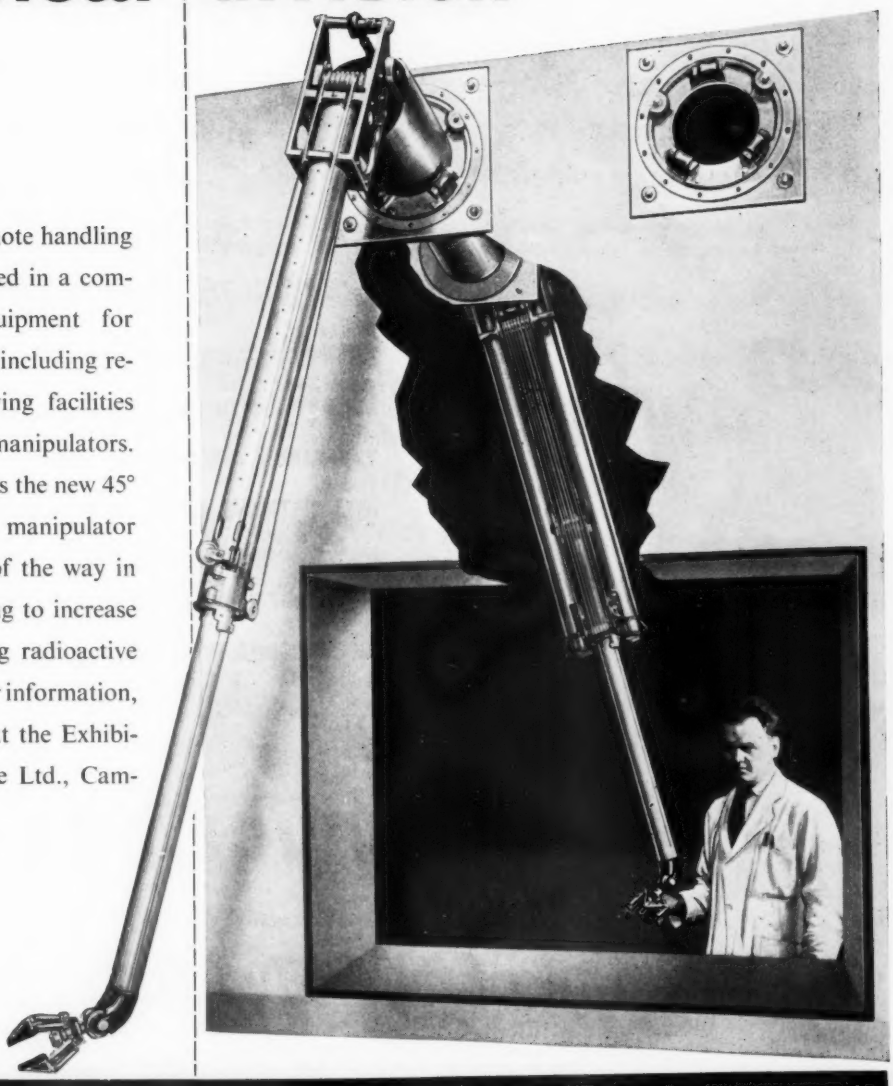

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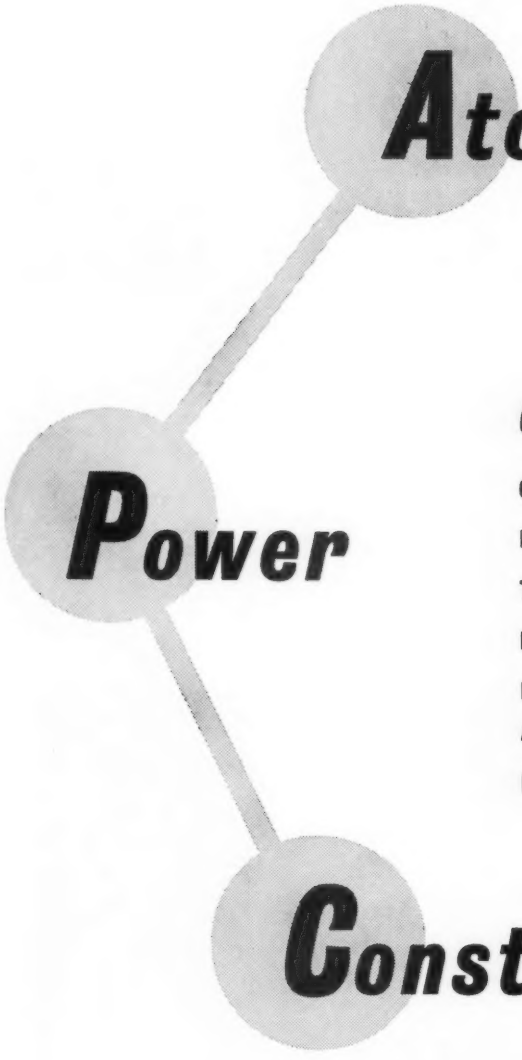

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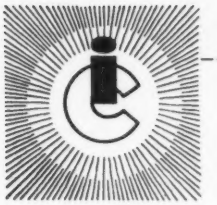

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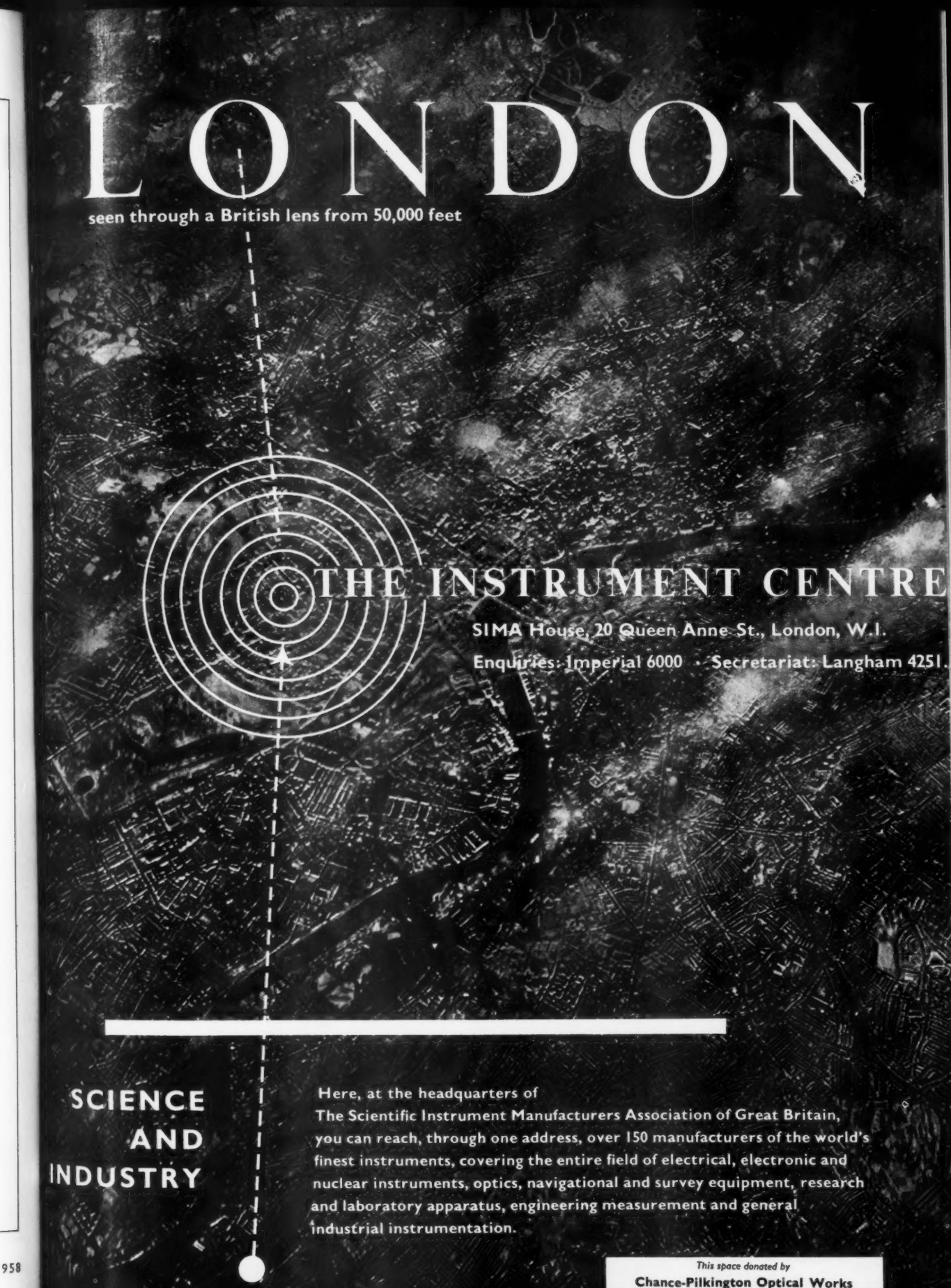
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JOHN BROWN
NUCLEAR CONSTRUCTION
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AT

STAND 141

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The operating Companies employ more than 100,000 people and cover the complete field from feasibility studies (both Nuclear and Mechanical), through Research, Development and Design to Construction and Commissioning.

Among the exhibits is a representation of an advanced plant for the production of Heavy Water and there are, in addition, models illustrating items developed by the various Companies which are of special interest in the Nuclear field.

Lo Stand della H. S. J. B. è la dimostrazione delle vaste risorse a disposizione dei Gruppi Hawker Siddeley e John Brown e che la nuova Società può devolvere alla soluzione dei problemi nucleari di qualsiasi genere.

Le Società attive hanno un personale di oltre 100.000 dipendenti e trattano l'intero campo, dagli studi di fattibilità (sia nel settore nucleare che meccanico) attraverso le ricerche, i perfezionamenti e la progettazione. alla costruzione e messa in opera.

La gamma in esposizione comprende il modello di un impianto moderno per la produzione di acqua pesante e modelli di applicazioni perfezionate dalle varie Società di particolare interesse nel settore nucleare.

Der Stand der H. S. J. B. zeigt die umfangreichen Mittel der Hawker Siddeley Gruppe und der John Brown Gruppe, die für die Lösung von Kernproblemen aller Art bei dieser Gemeinschaftsgesellschaft zur Verfügung stehen.

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Le Stand H. S. J. B. démontre les vastes ressources du Groupe Hawker Siddeley et du Groupe John Brown, ressources que la Société en Participation peut affecter à la solution des problèmes nucléaires les plus divers.

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Ever-increasing outputs of electricity from atomic power stations
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dispelling fog and domestic smoke
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But before these things come to pass,
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much of it breaking entirely fresh technical ground.
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They are specialists in the production and manipulation of tubes
and this specialised knowledge is freely at the disposal
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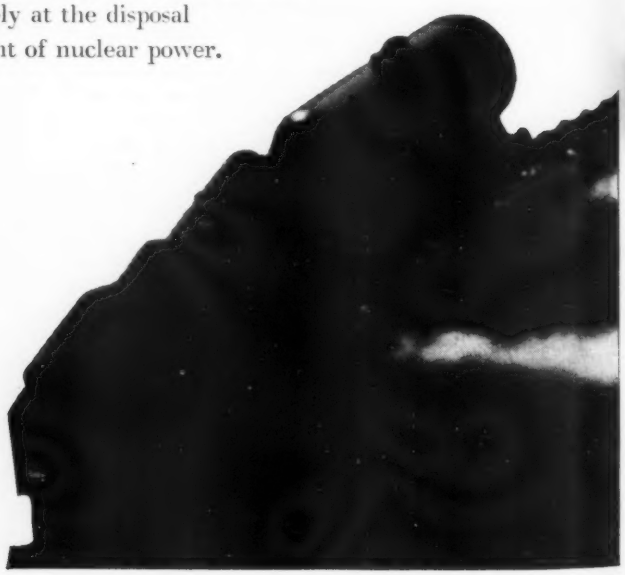

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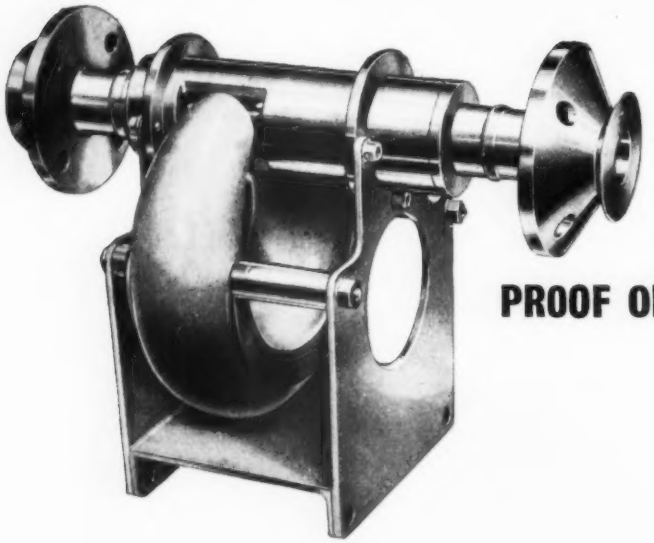

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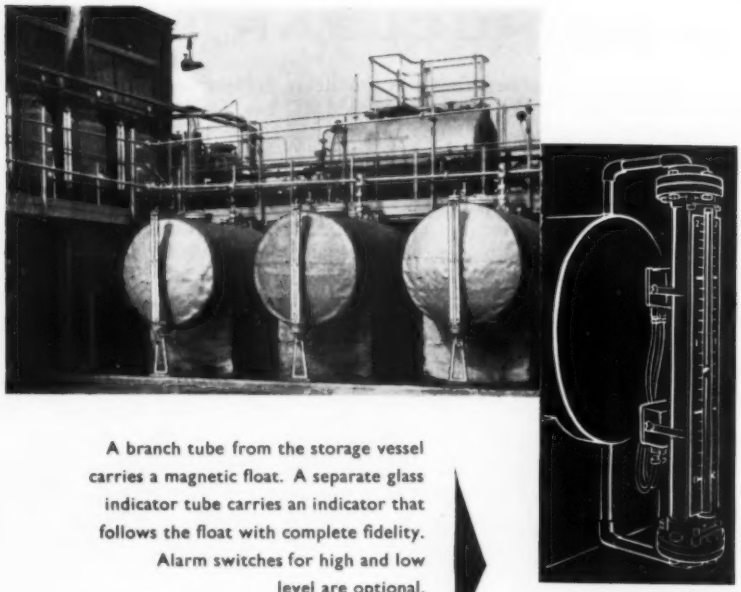

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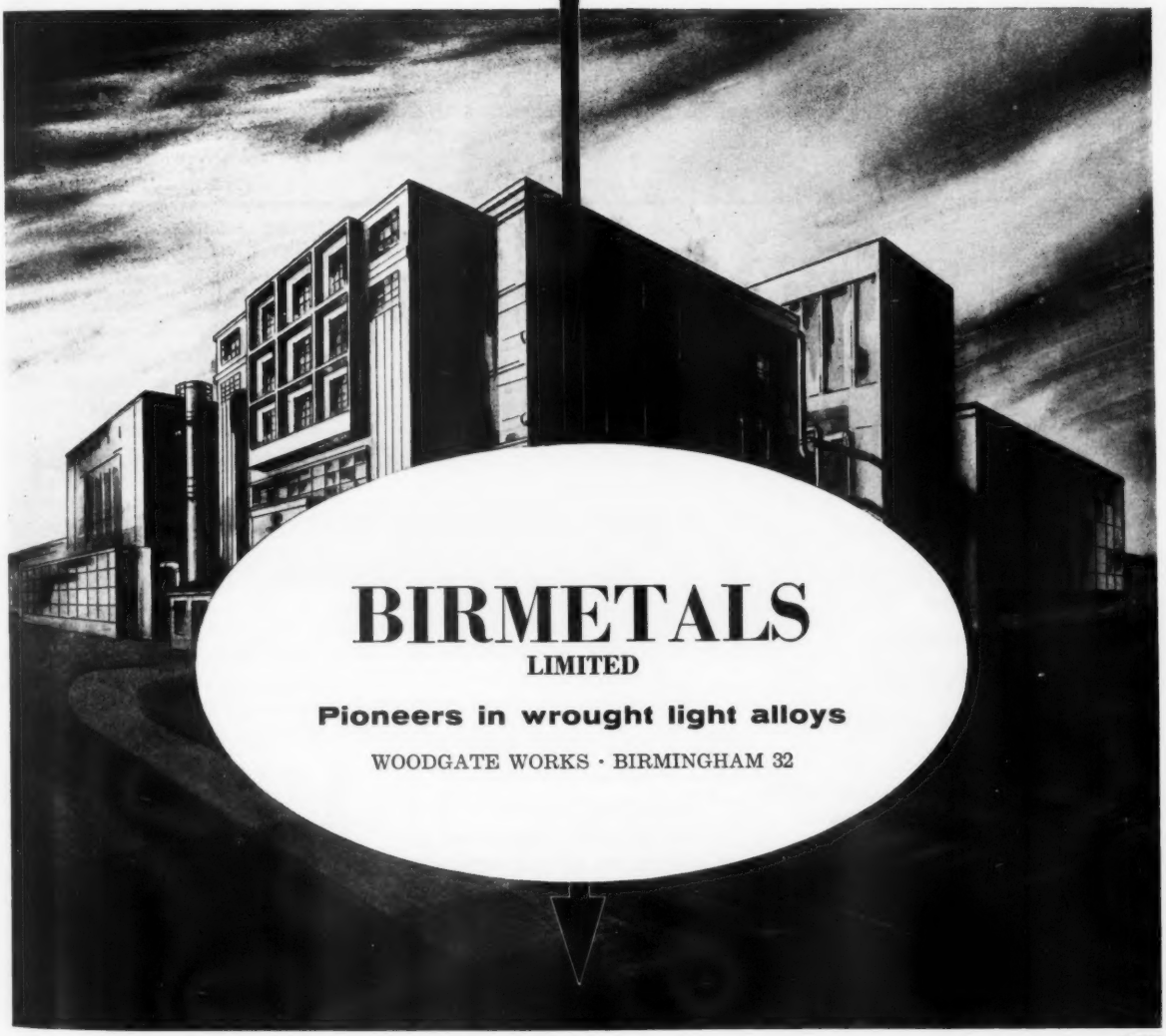

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Characterised by a very low natural leak, a high quality optical system and considerable mechanical strength, Stephen individual dosimeters are available in the ranges 0-0·2r, 0-0·5r, 0-5r, 0-50r, 0-150r, and 0-500r. Other ranges can be supplied to order. All except the 0·2r range are "air wall" construction.

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Pocket-size transistor charging unit has ample capacity with full control for charging all British-made pocket dosimeters. Weight 6 oz. (170 gms).

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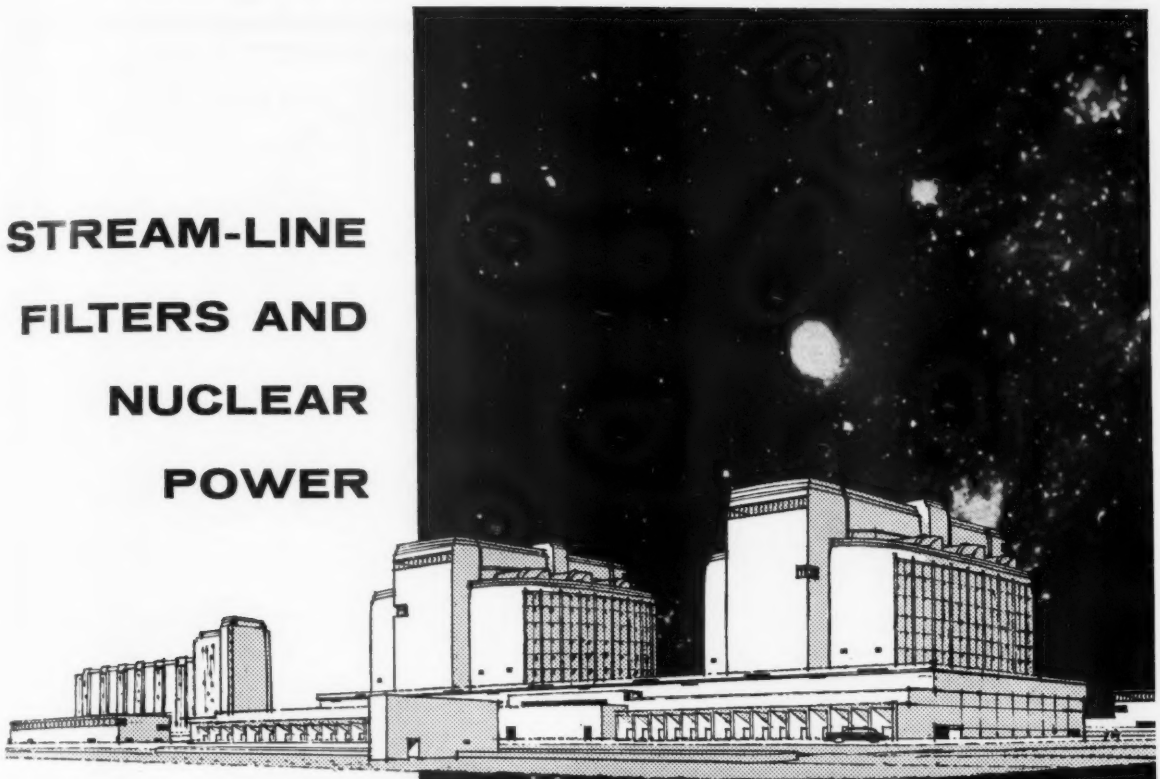
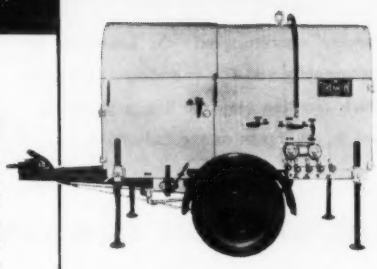
STREAM-LINE FILTERS AND NUCLEAR POWER



The security of oil-immersed circuit breakers or transformers depends on the condition of the oil. In Stream-Line filters the engineer has at his disposal equipment specially designed for the complete removal of contamination in insulating oil and which meets the most stringent requirements. That's why Stream-Line filters have been specified for Chapel Cross and Berkeley, and are in wide use throughout the U.K.A.E.A. A single passage through a Stream-Line filter ensures the elimination of solid impurities, even the finest colloidal carbon; dehydration, including the removal of dissolved water, and de-aeration, including the removal of dissolved gases. A dielectric strength far above that specified for the highest quality new oil is achieved by a standard Stream-Line filter. Our research and development department will be glad to answer your queries. Write for Catalogue W.1031.

A WORD ABOUT HIGH VACUUM

Stream-Line filters designed to operate under high vacuum can be supplied. Details are available on request of models yielding remarkable performances. For most requirements the standard Stream-Line filter gives precisely the service demanded.



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★ One group required thin walled capillaries of plastic phosphor N.E. 102 for flow counters. We were able to produce them in a fortnight and advise on their use in many important applications.

★ A research establishment wanted thousands of 1 mm rods (or filaments) of plastic phosphor, for nuclear track scintillation chambers. We worked out an economical method for producing them, thus making this interesting new technique readily available.

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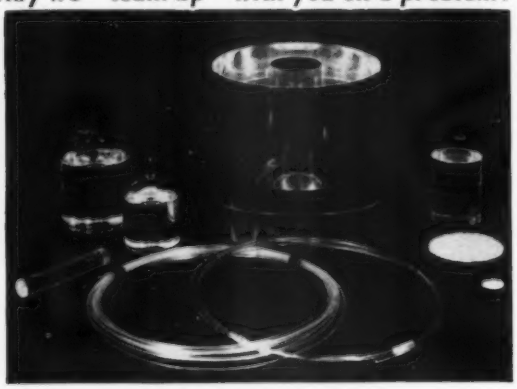

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Nuclear Enterprises (G.B.) Ltd.

Bankhead Medway, Sighthill, Edinburgh, 11, Scotland. Telephone: CRAiglockhart 4513

Associate Company: Nuclear Enterprises Ltd., 1750 Pembina Highway, Winnipeg, Canada.

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"Once more
unto the breach
dear friends,
once more"

A long time has passed since the clarion call of Henry V rang over the battlefields of France. The days of hauberk, gauntlet and lance have gone for ever and the dreams for which men fought and died are forgotten. There are still battles to be won, but not on the bloody fields of Crecy, Agincourt, or Flanders, or with the clumsy impedimenta of war. The time is the present and the struggle is for power: power for industry, and at Dounreay the United Kingdom Atomic Energy Authority are developing the means to produce more and cheaper power for all.

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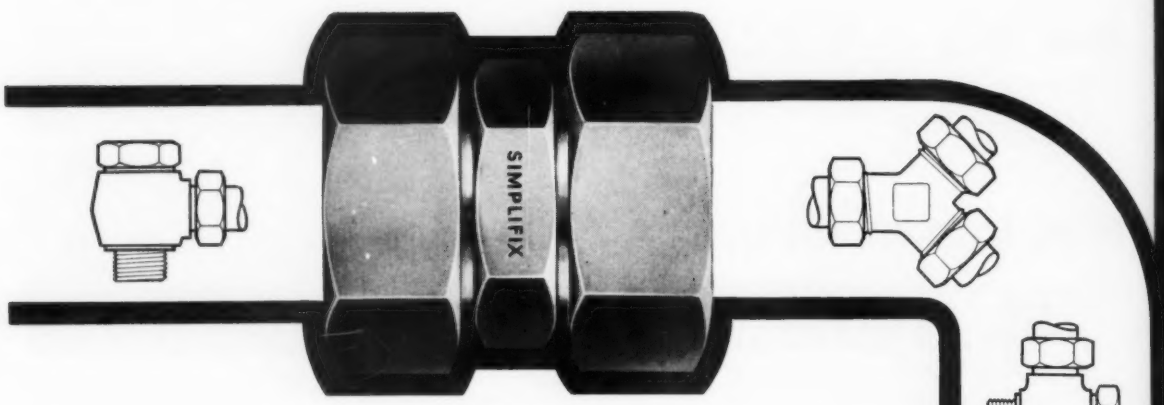

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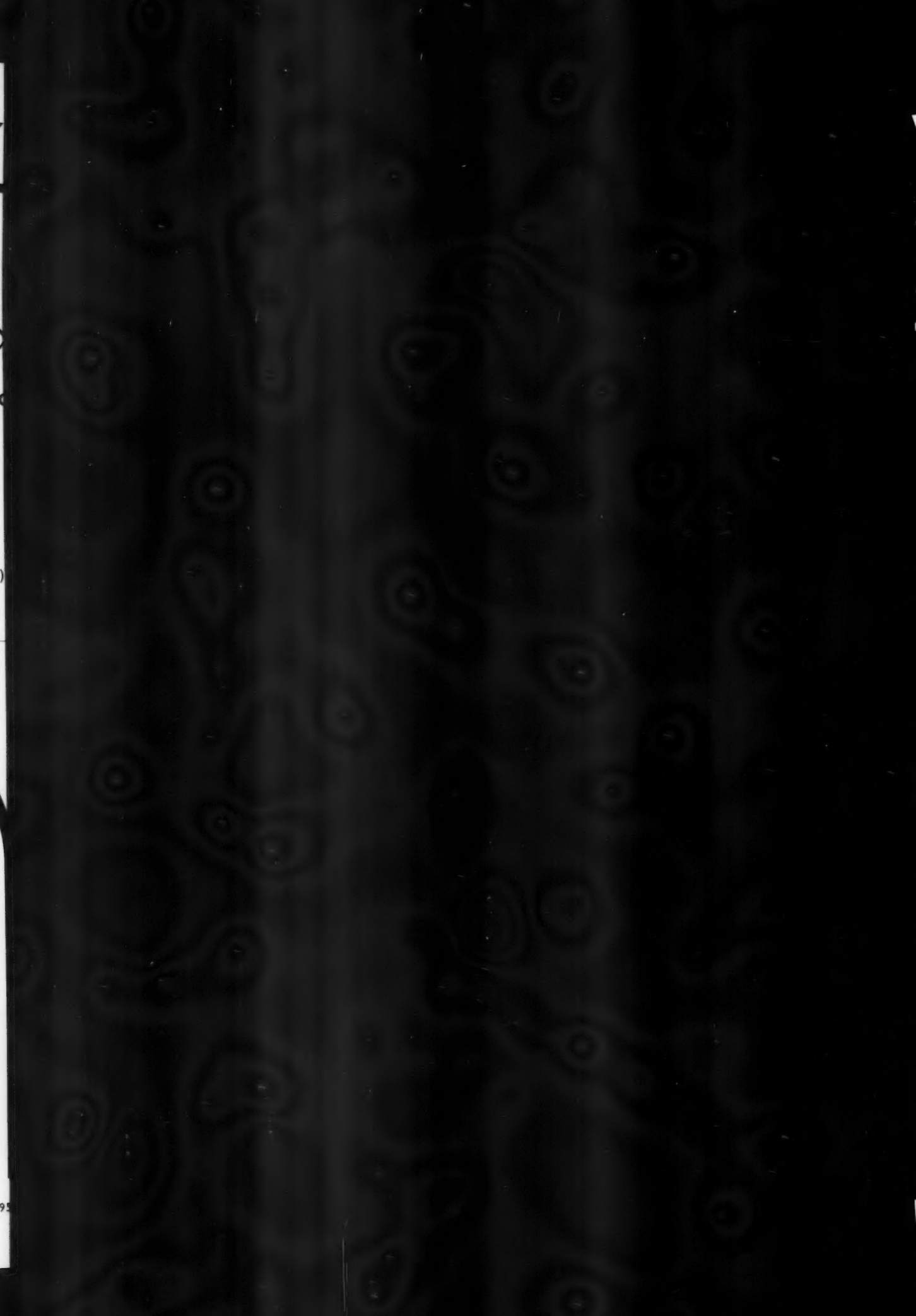

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- ☐ Powell Duffryn Carbon Products Ltd A6
- ☐ Union Carbide International Co A37

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- ☐ Imperial Chemical Industries Ltd (Corvic div) A25
- ☐ Mallinckrodt Chemical Works A66-A67
- ☐ Nash & Thompson Ltd A88
- ☐ Nuclear Enterprises (GB) Ltd A98
- ☐ Nuclear Materials and Equipment Corp A13
- ☐ Paul Ltd, K. S A129

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- ☐ Sankey-Sheldon Ltd (Unistrut Division) A39
- ☐ Simms Sons & Cooke Ltd A111
- ☐ Skinningrove Iron Co Ltd A7

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- ☐ British Paints Ltd A17
- ☐ England, Hughes, Bell & Co Ltd A76

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- ☐ Bryan Savage Ltd, W. A130
- ☐ Electro-Hydraulics Ltd A19
- ☐ Hawker Siddeley-John Brown Nuclear Construction Ltd A85
- ☐ Internuclear Co A81
- ☐ Kingston Instrument Group A126
- ☐ Wilson Partners Ltd, A. C. A69

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- ☐ Electropower Gears Ltd A116
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- ☐ Crossley Bros Ltd A98
- ☐ Metropolitan-Vickers Electrical Co Ltd A97

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- ☐ Aerox Ltd A96
- ☐ Birfield Industries Ltd A99
- ☐ Endecotts (Filters) Ltd A130
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- ☐ Stream-Line Filters Ltd A95
- ☐ Vokes Ltd A4

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- ☐ Kidde Co Ltd, The Walter A73

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- ☐ Boving & Co Ltd A53
- ☐ C. T. (London) Ltd A129
- ☐ Doulton Industrial Porcelains Ltd A132
- ☐ Erhard, Johannes A56
- ☐ Howden & Co Ltd, James Cover 2
- ☐ Magnetic Valve Co Ltd, The A58
- ☐ Pressure Control Ltd A130
- ☐ Pulsometer Eng Co Ltd, The A102
- ☐ Worthington-Simpson Ltd A5

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- ☐ Metalectric Furnaces Ltd A125

Industrial films, books, models and exhibitions
- ☐ Atoms for Peace Exhibition A131
- ☐ Nuclear Reactor Physics A123
- ☐ Control A118, A119
- ☐ Dendy & Associates, Richard A127
- ☐ Nuclear Power Year Book A114
- ☐ Rocol Ltd A84
- ☐ Turners Film Productions A96

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- ☐ Ekco Electronics Ltd 455
- ☐ Electronic Associates Inc A117
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- ☐ Fielden Electronics Ltd A15
- ☐ General Radiological Ltd A112
- ☐ Hobson Ltd, H. M. A115
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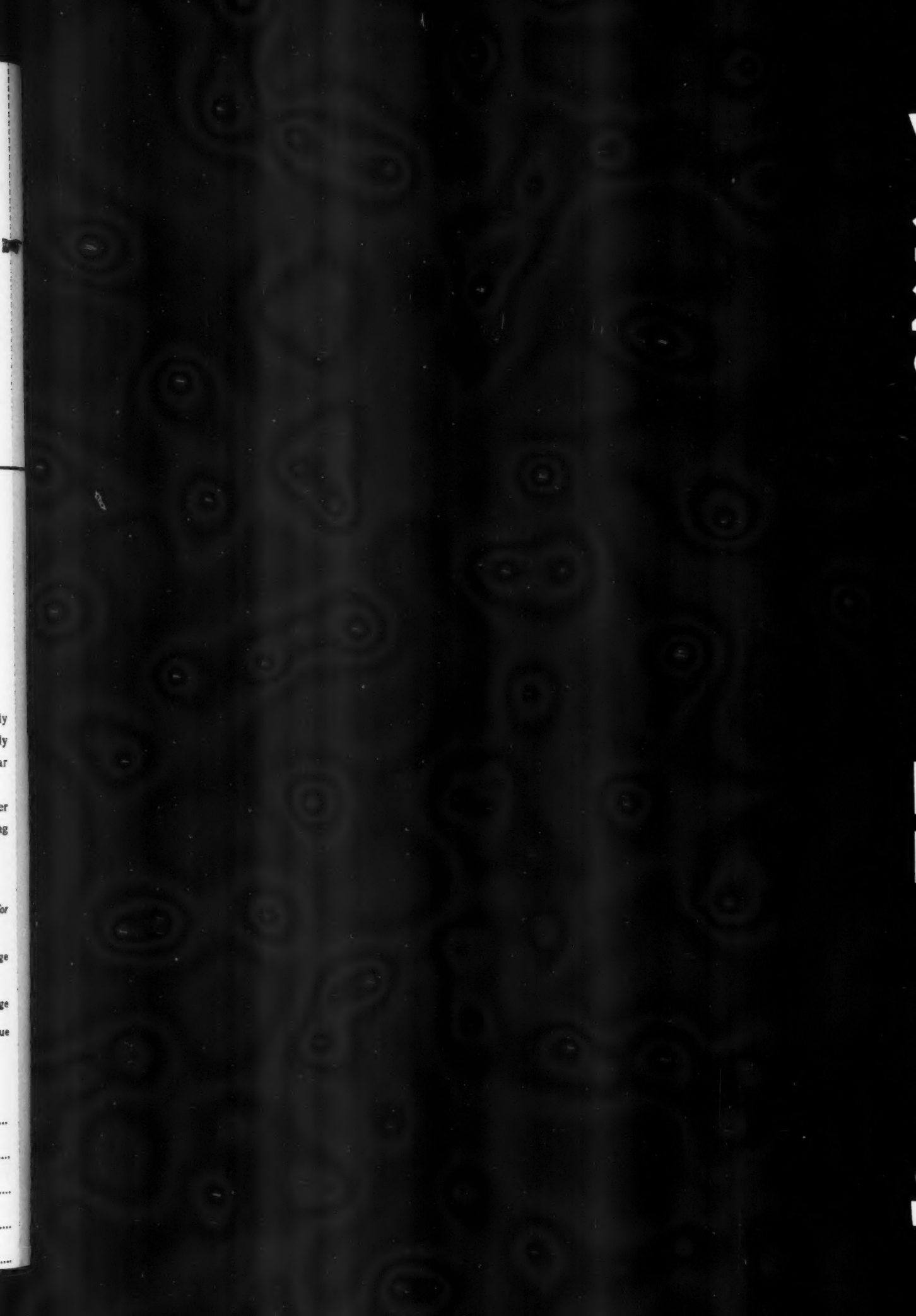

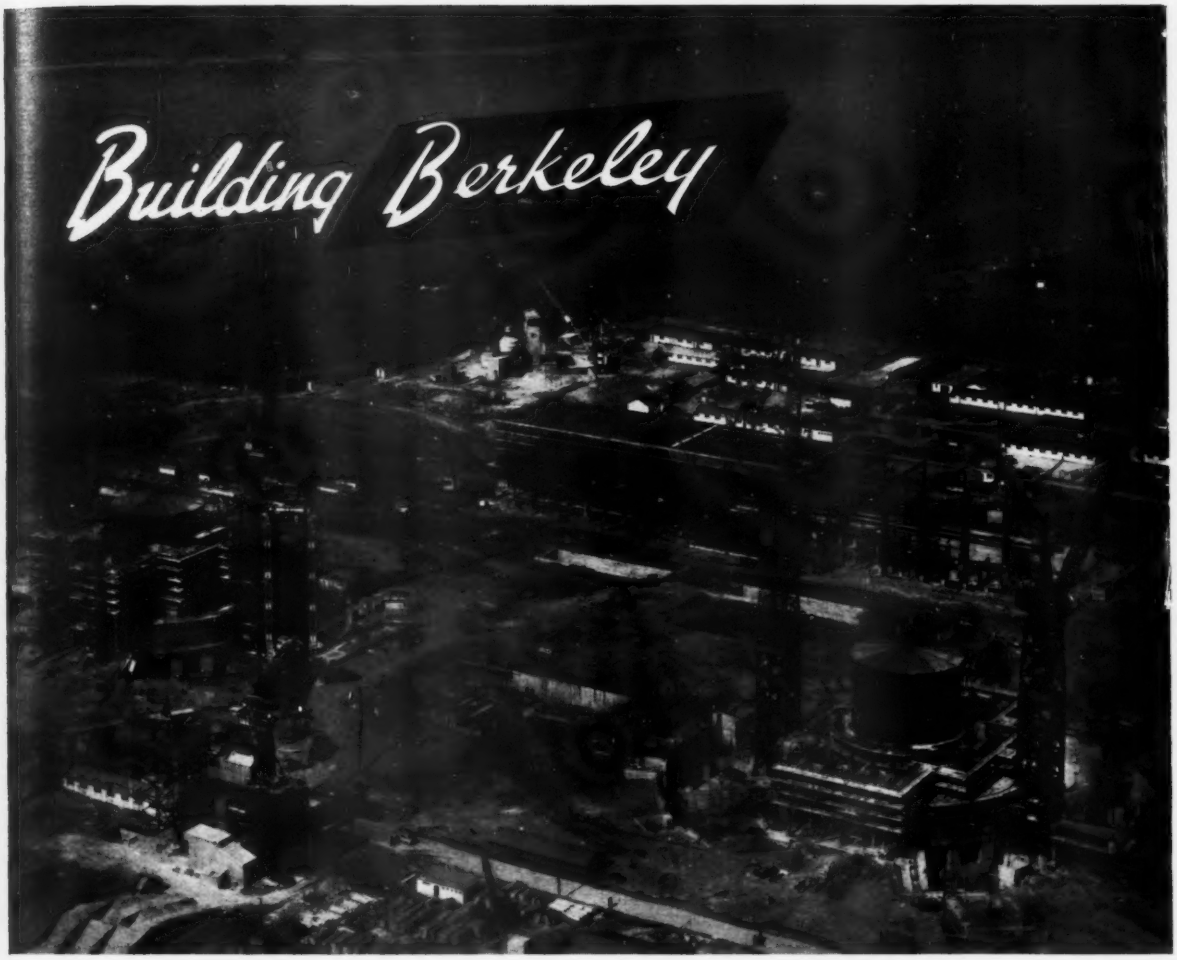

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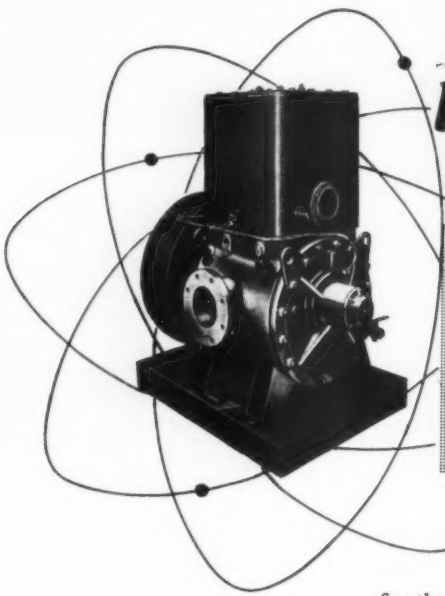

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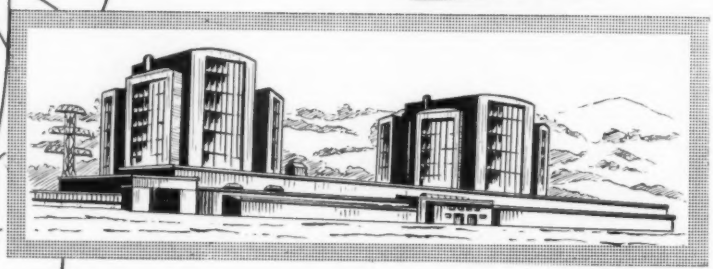

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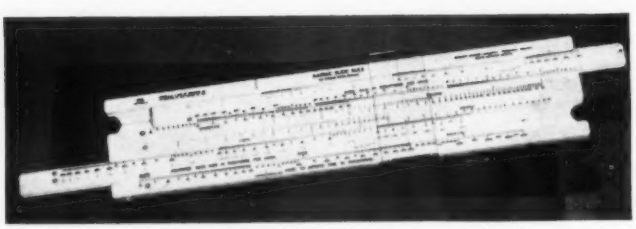

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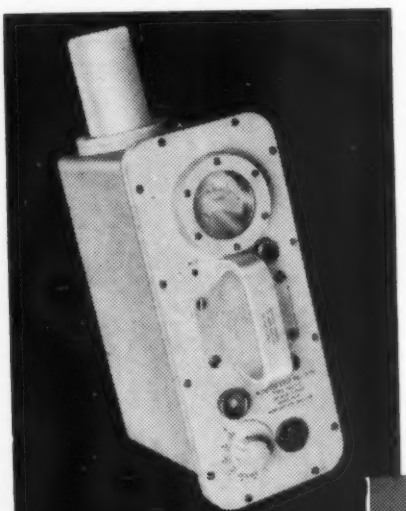

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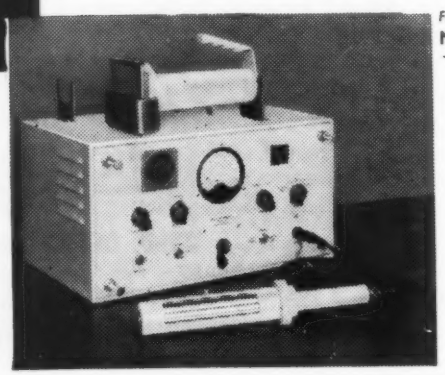

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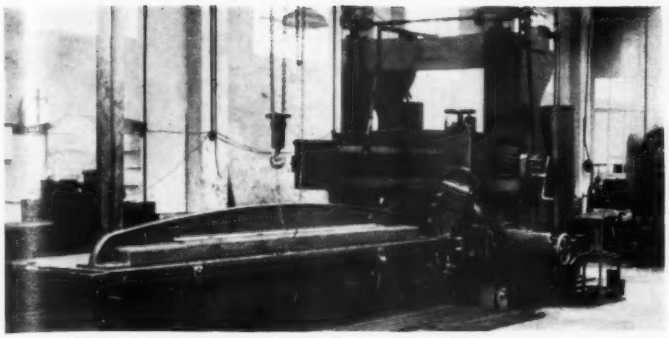

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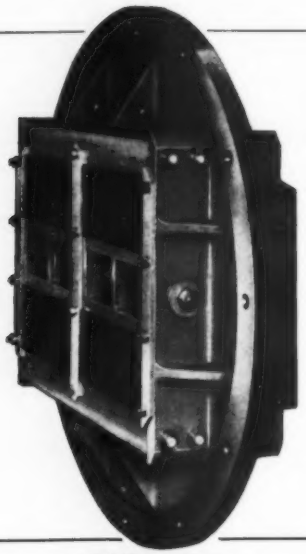

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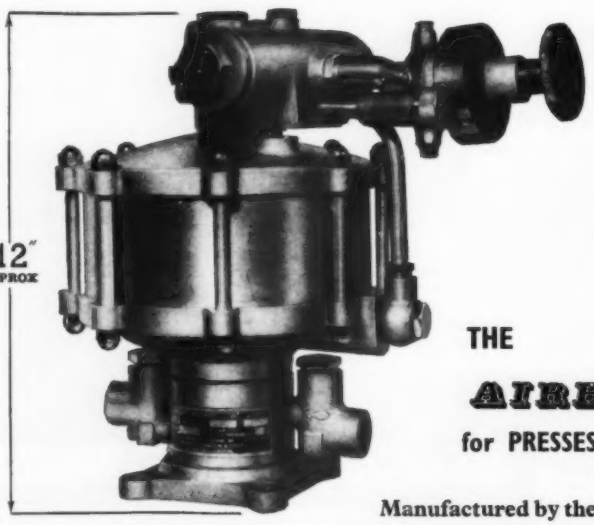

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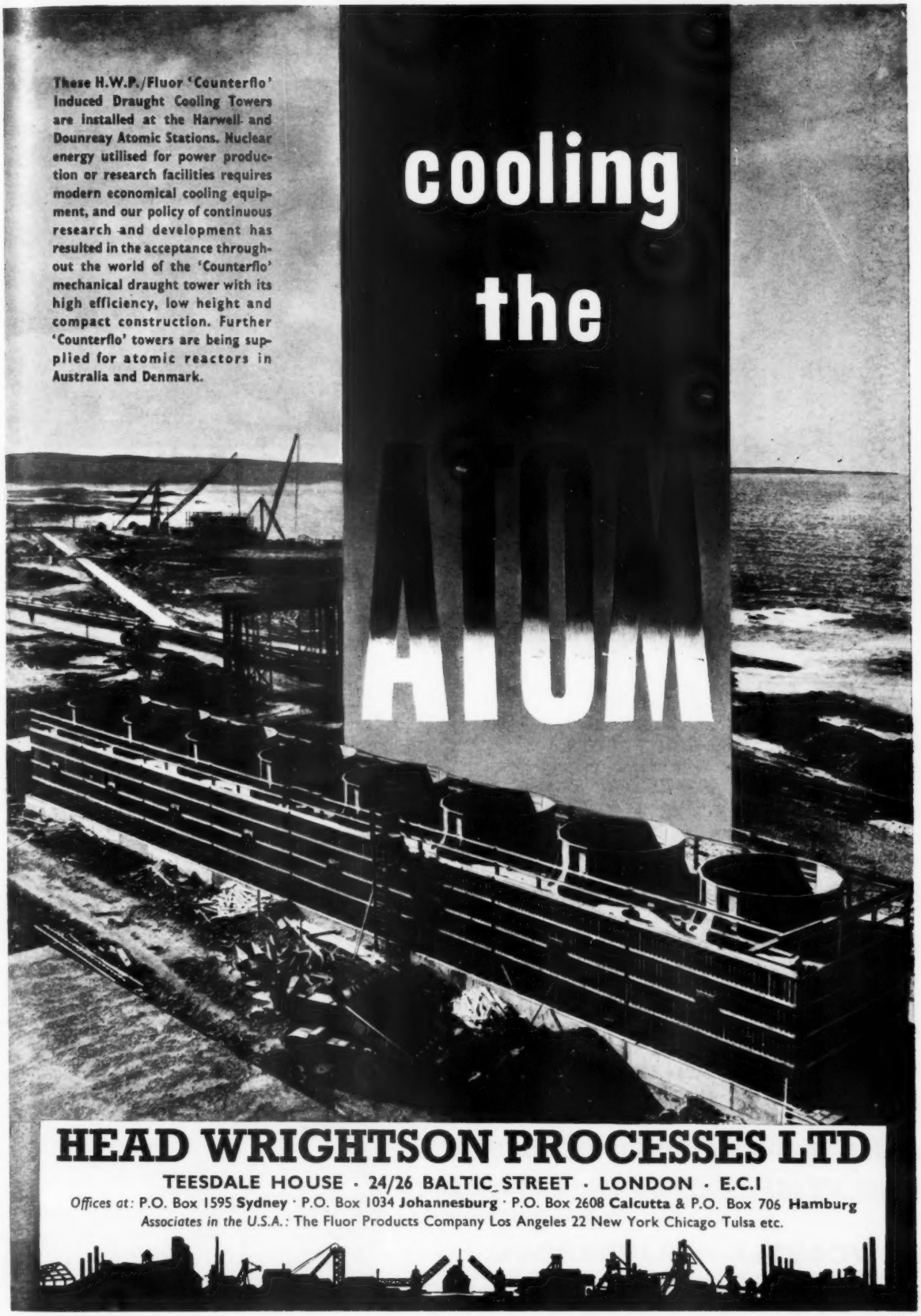
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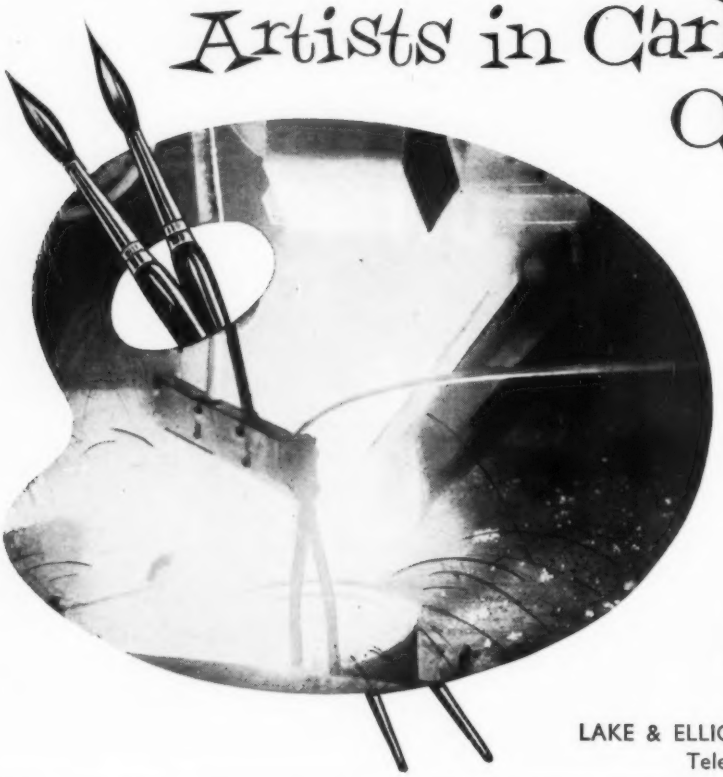

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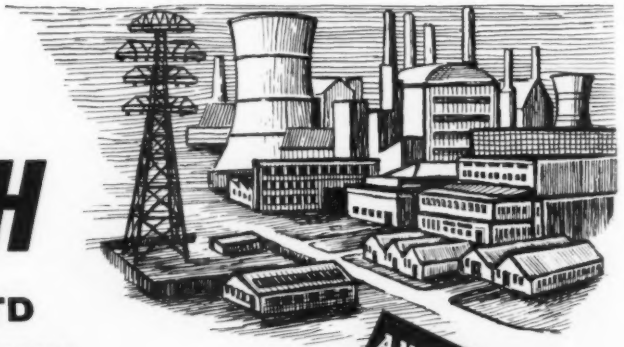

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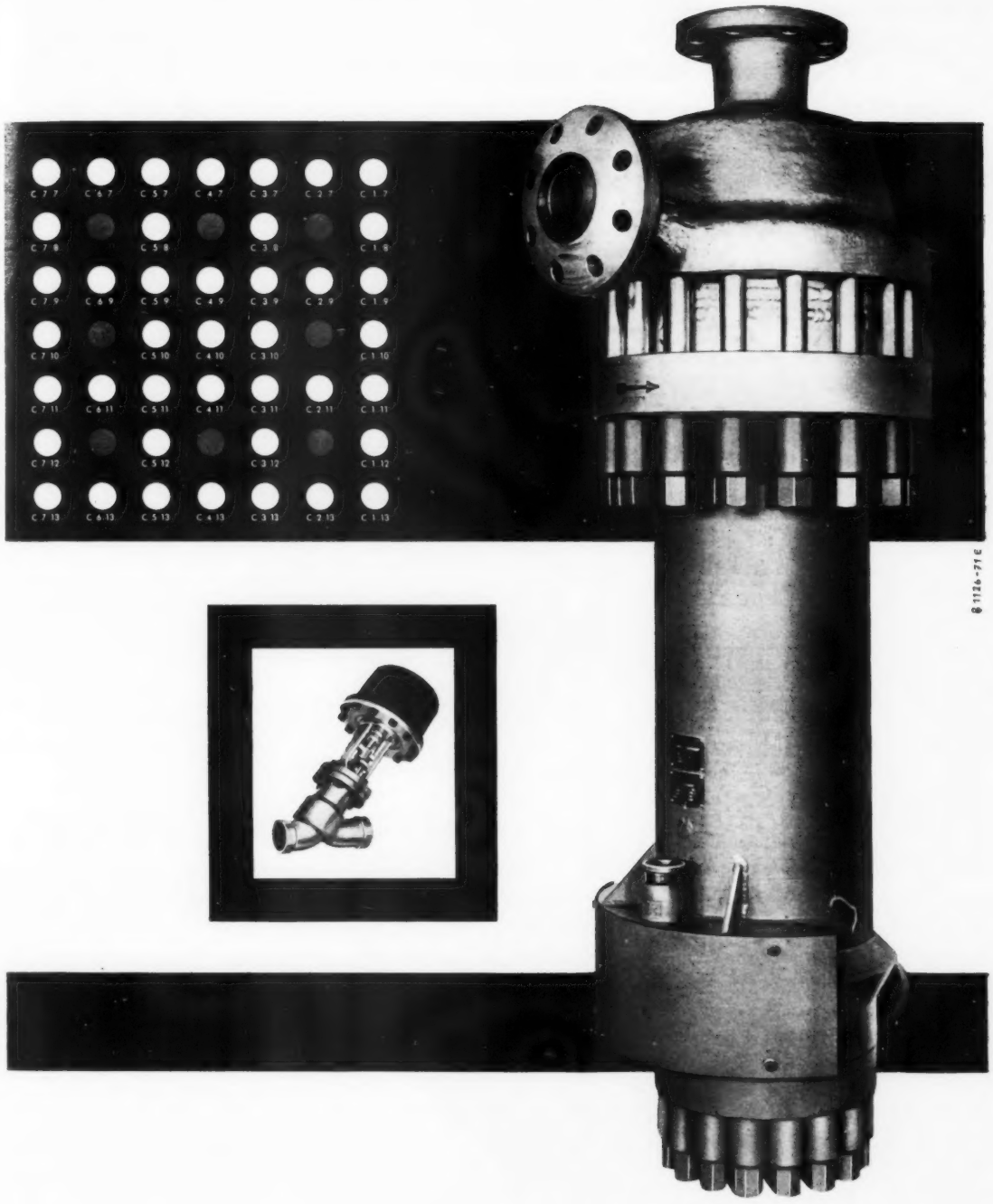

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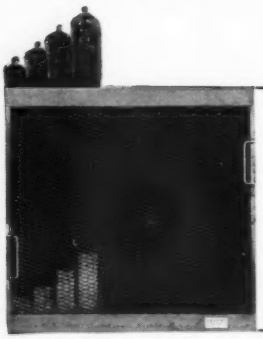
Not that we ever expect Doctors, Chars or Dustmen to buy them, of course. We certainly do not! But, you *must* agree that all they say about a Heather Air Filter is perfectly true—just ask any of our customers!

filter fan-club?



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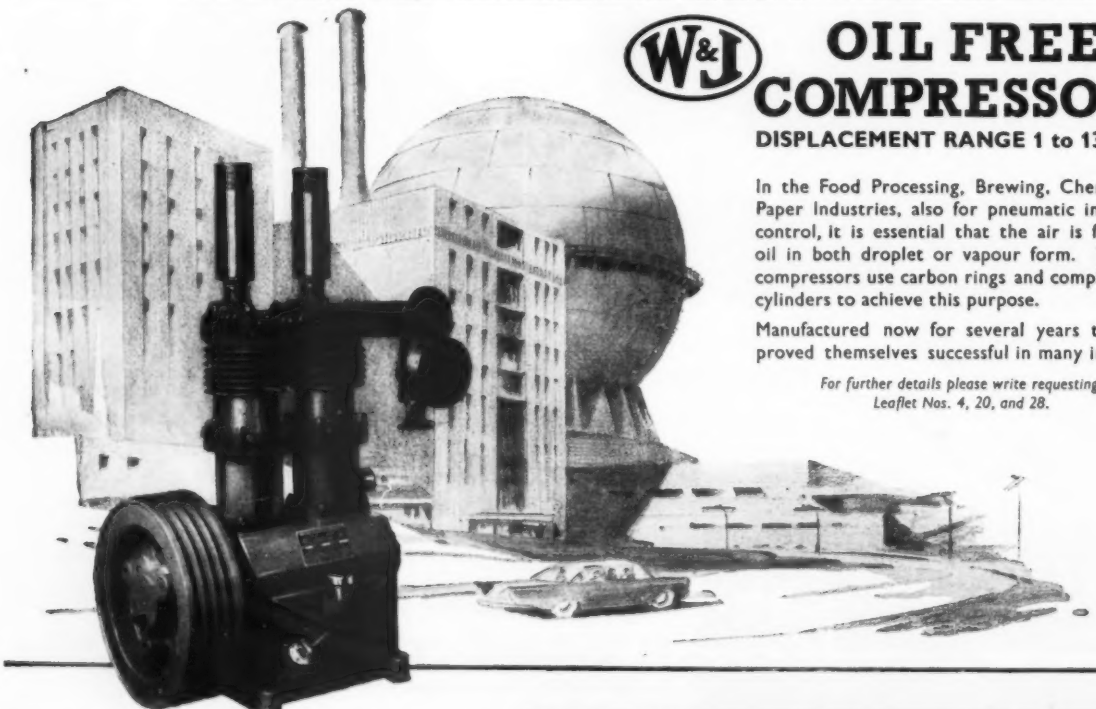

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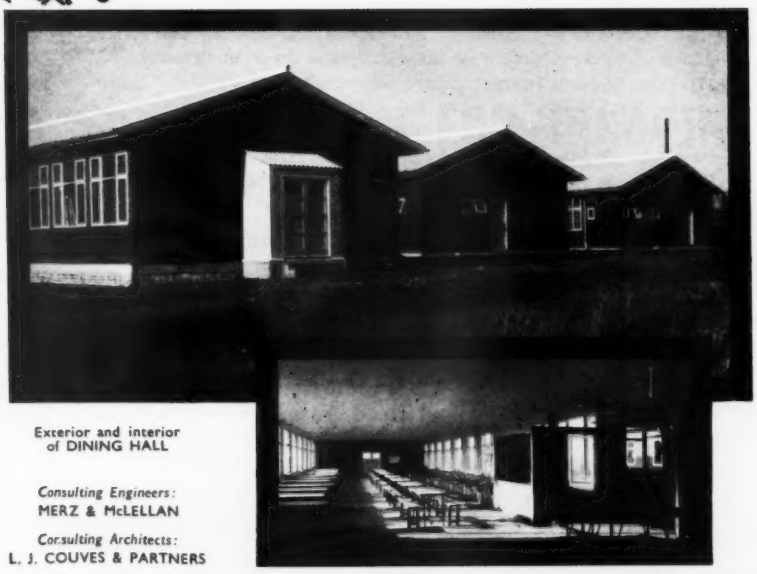

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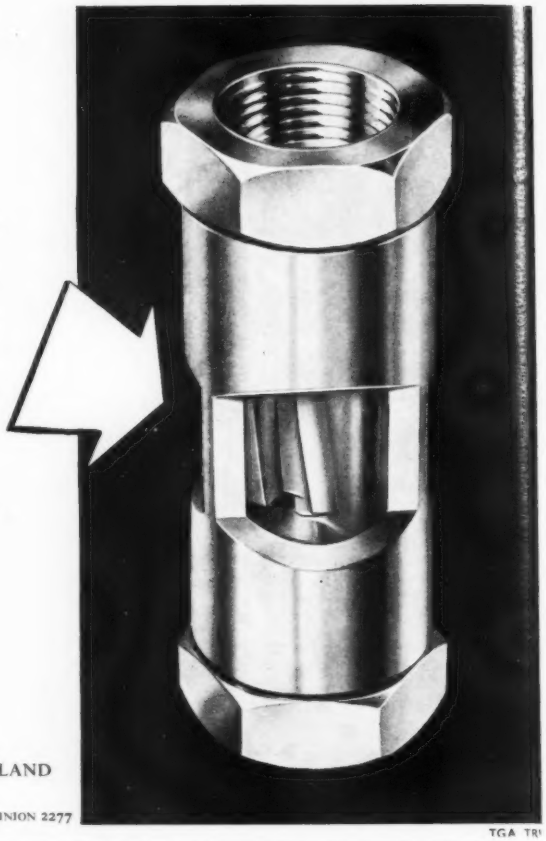

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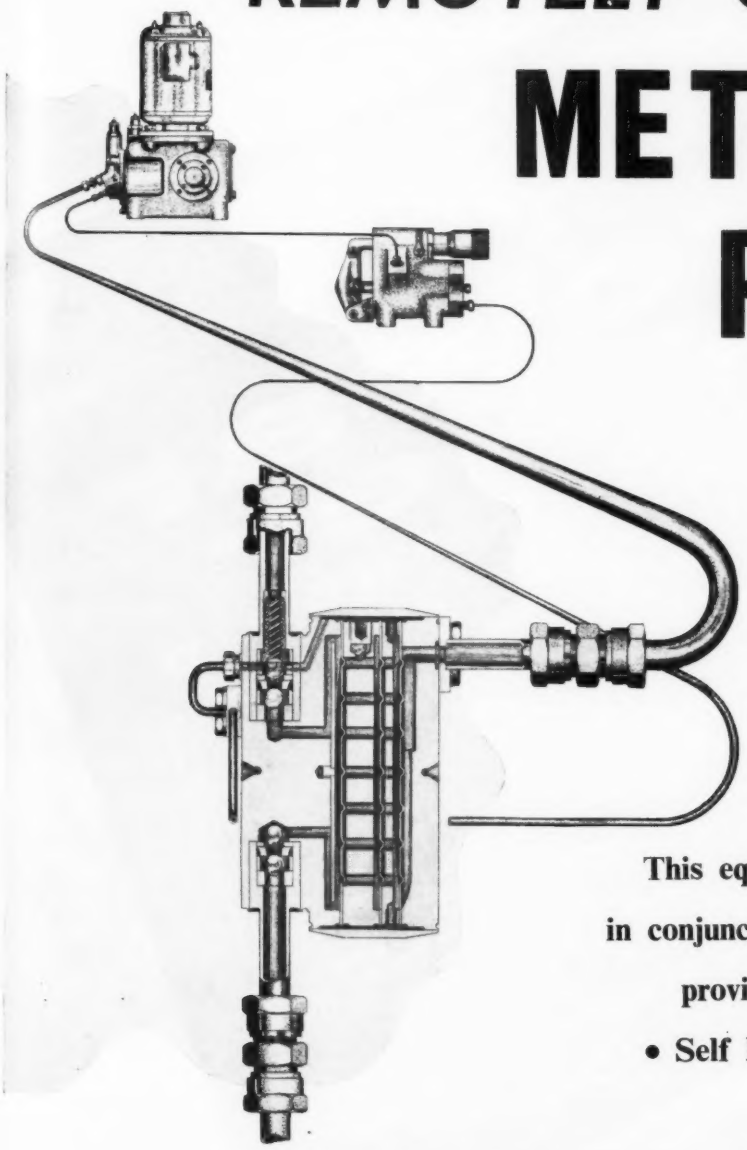

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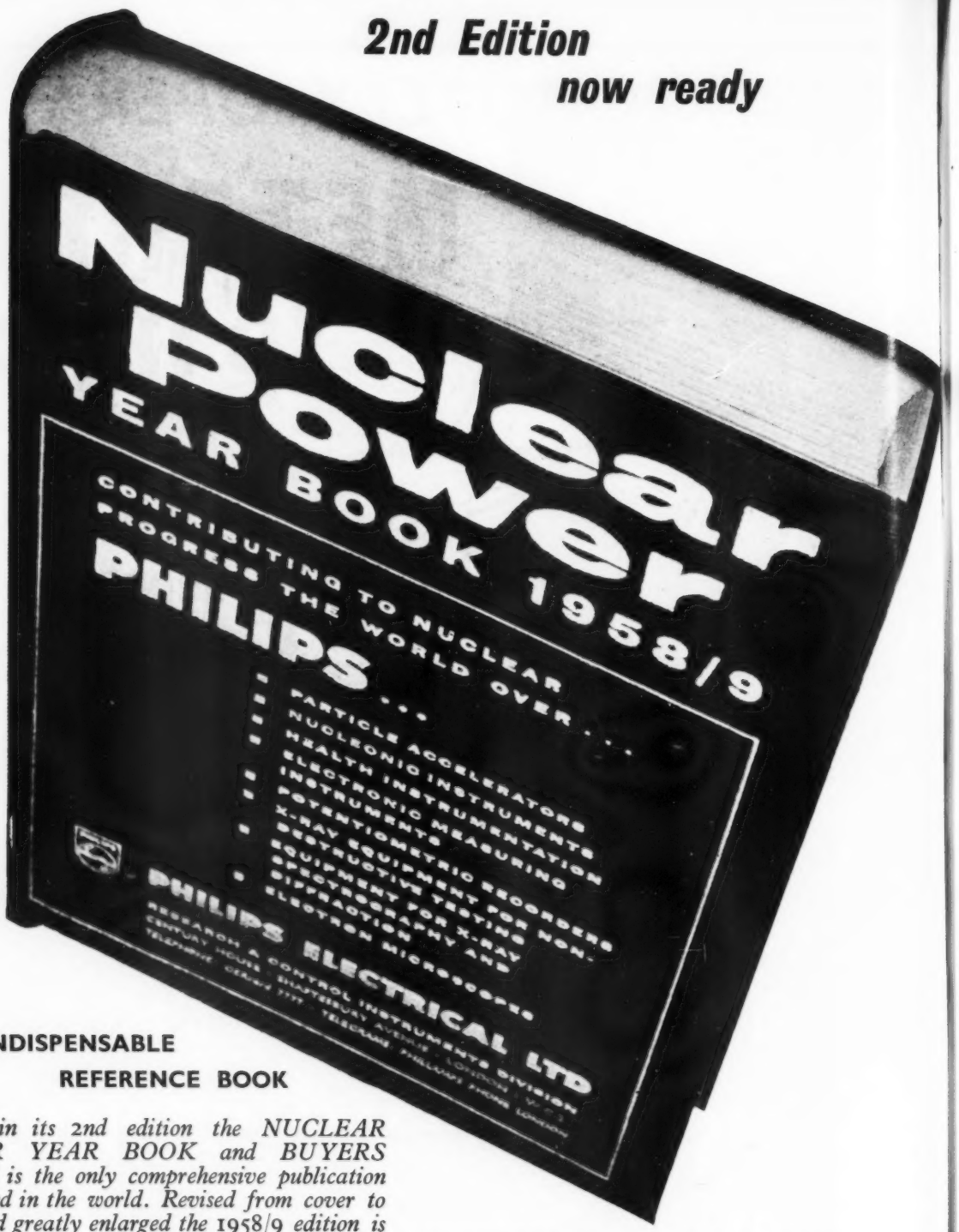
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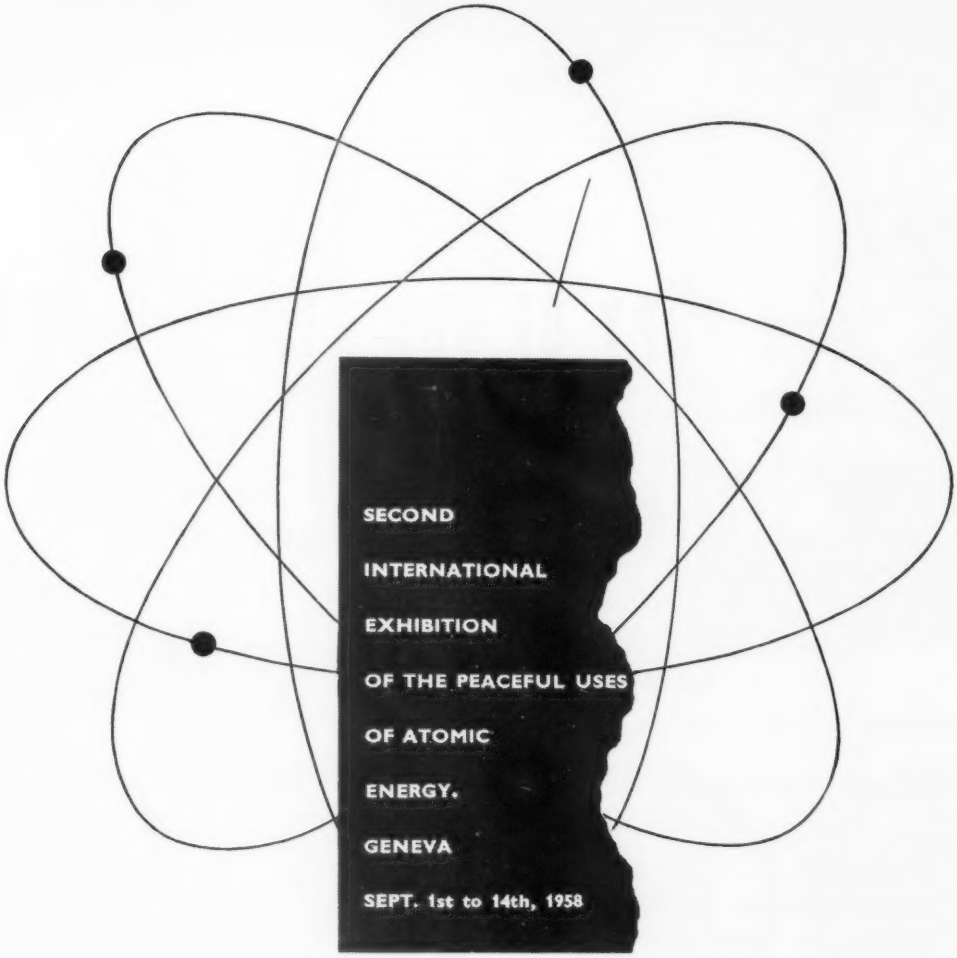

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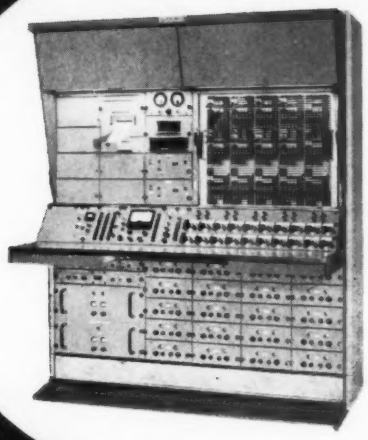

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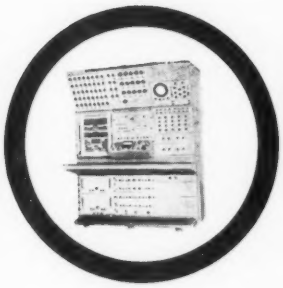

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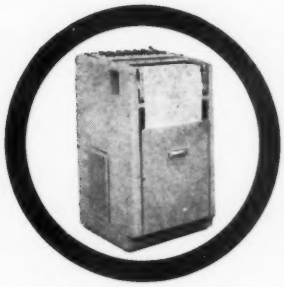

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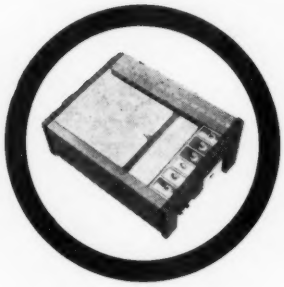

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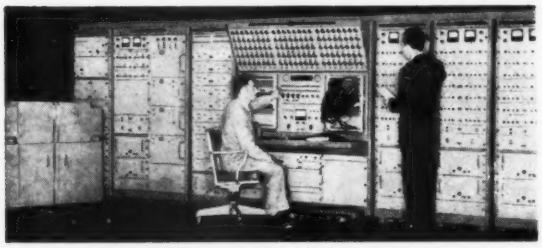

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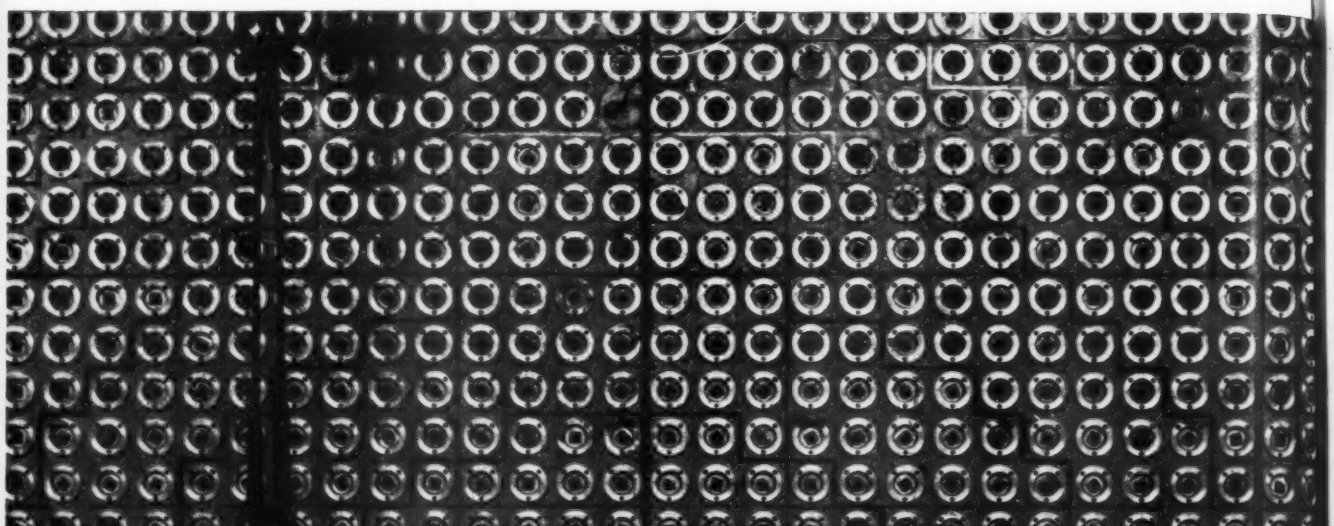

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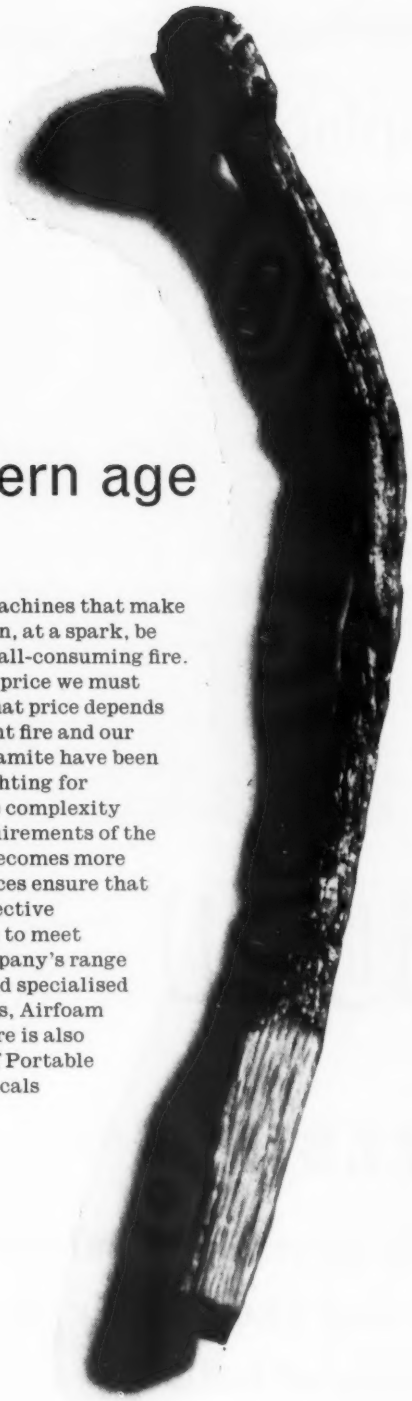

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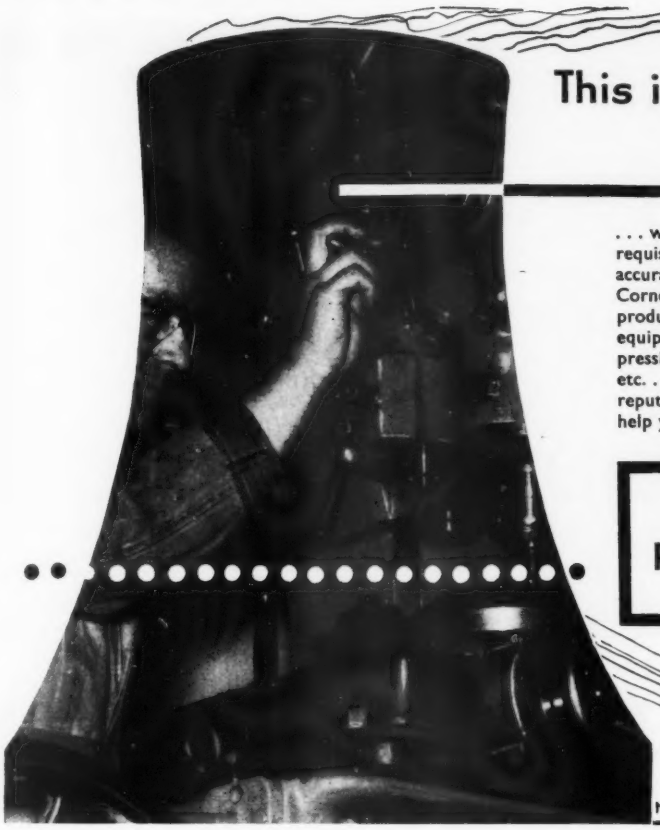

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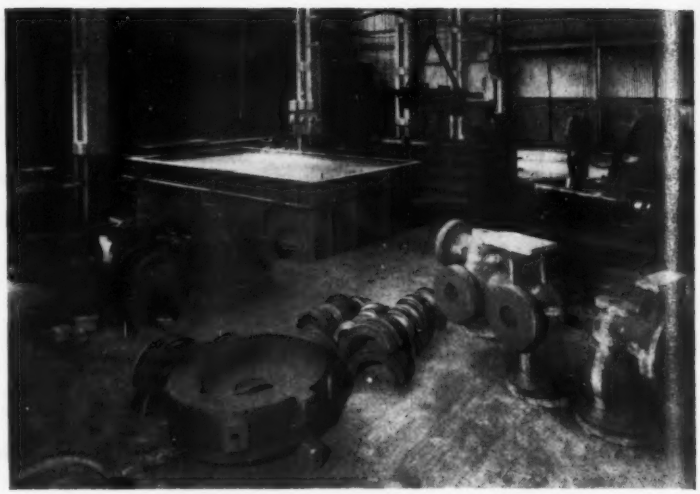

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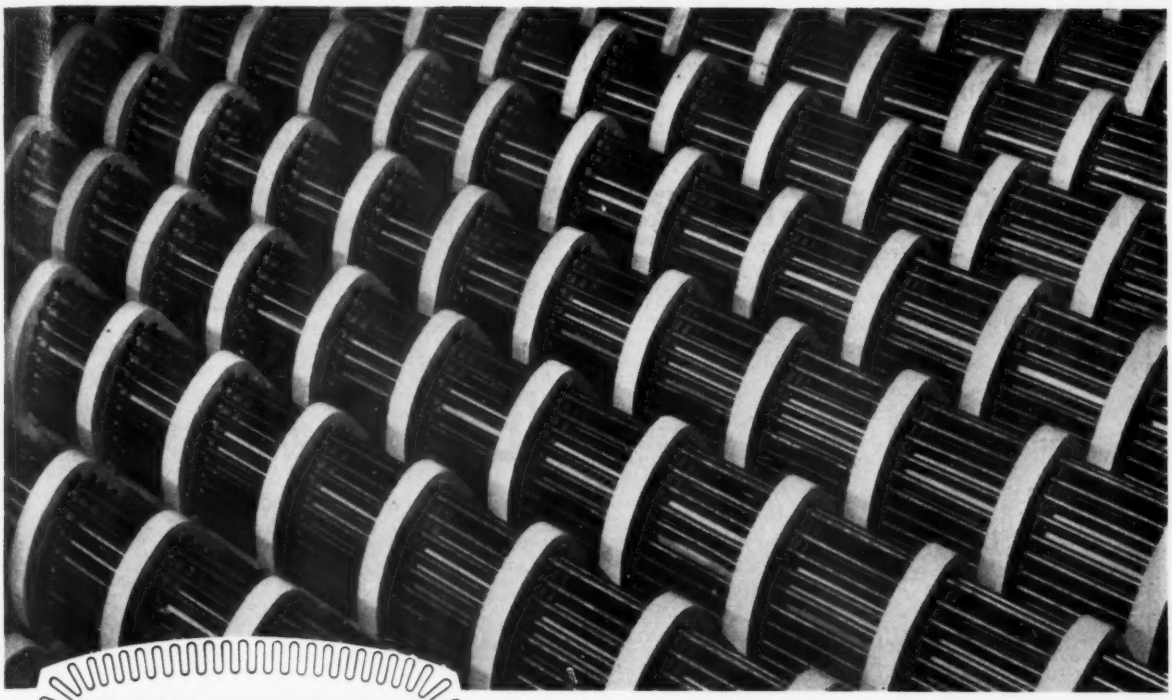

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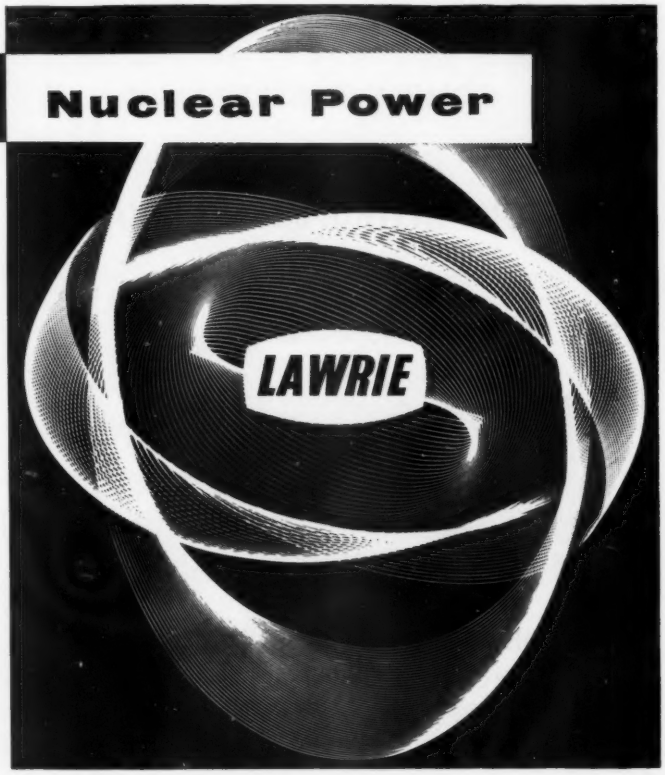

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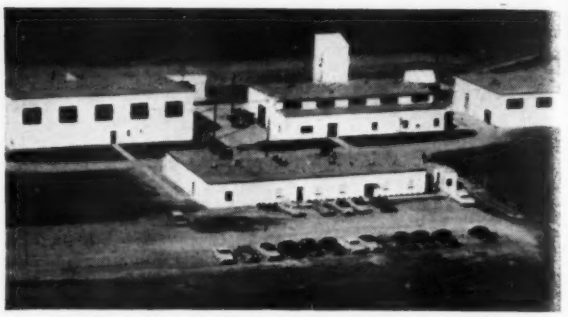

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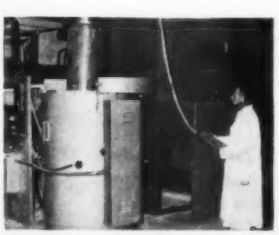
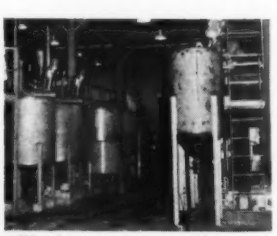
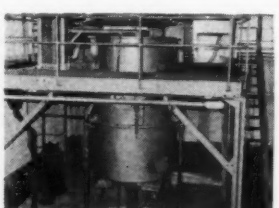


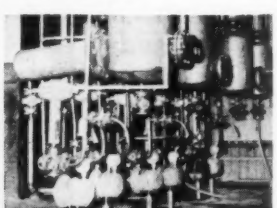
Reduction furnace showing charge of thorium being removed in bomb-type retort.



"Wet" area where uranium and thorium materials are processed in liquid media.



Vacuum induction melting furnace can make 1,200 lb. uranium ingots, designed for alloying and special castings to 3,000 lb.



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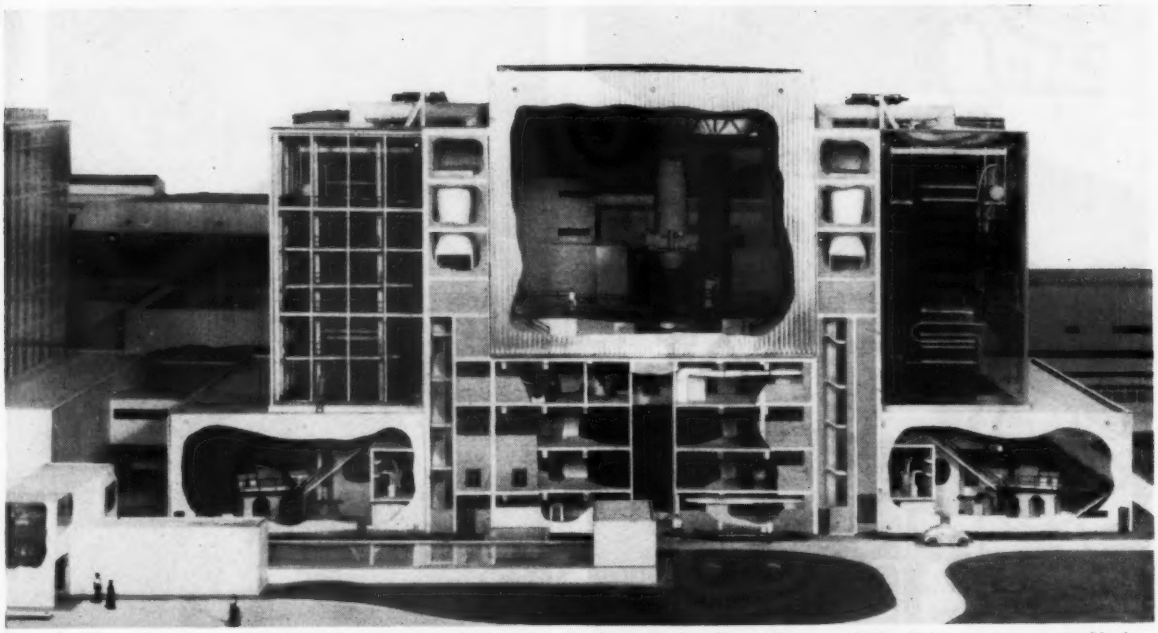

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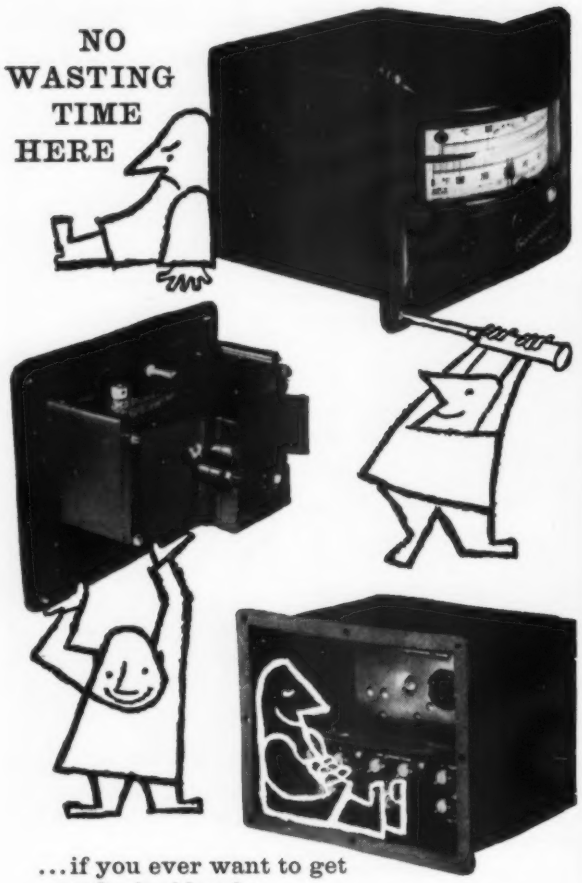

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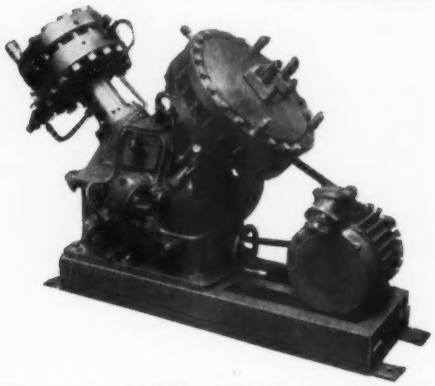

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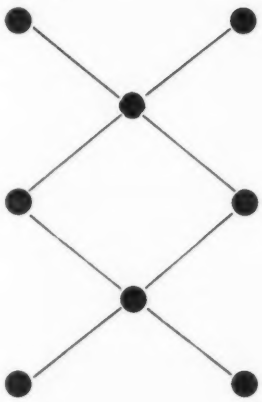

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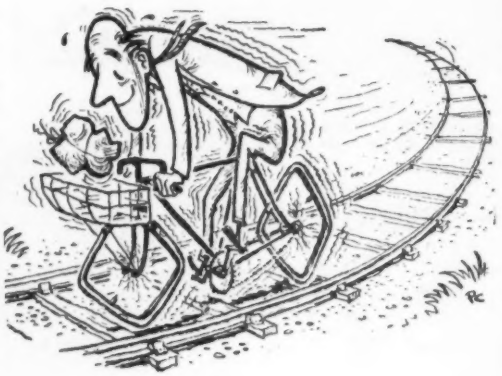

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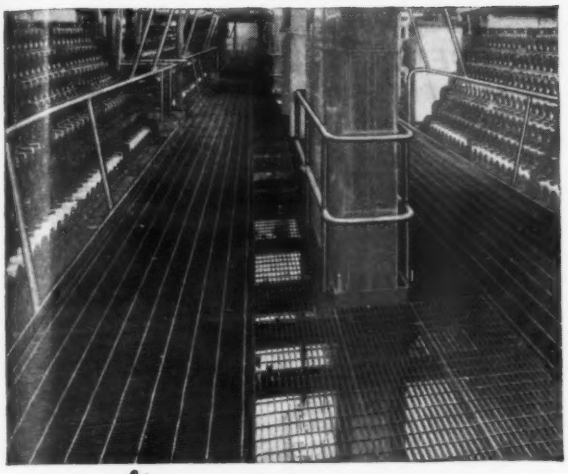

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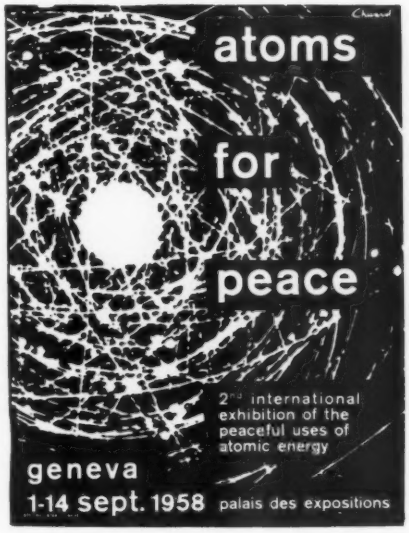

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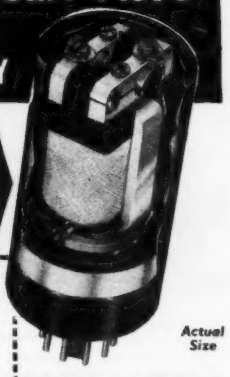

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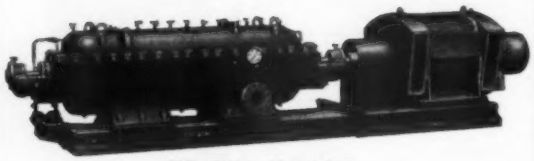

FIG. 4508M. 12 STAGES

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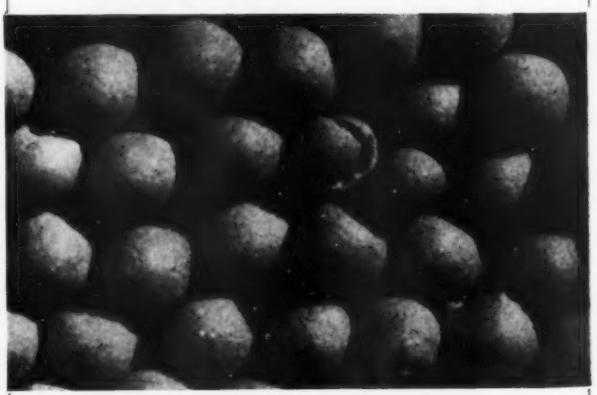

that this picture shows a clutch of turtles' eggs? Maybe you're not too sure.*

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* *(The "eggs" are really the heads of matches.)*

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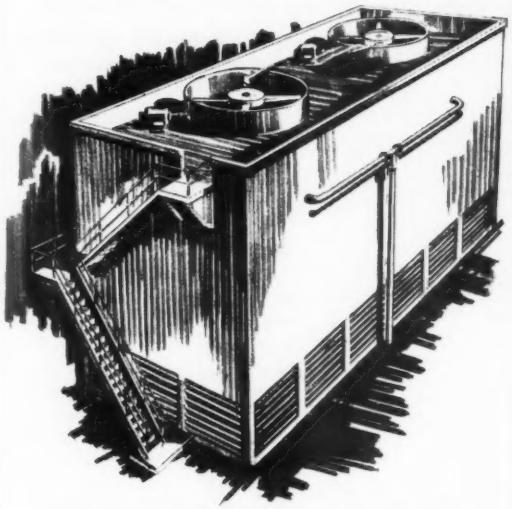

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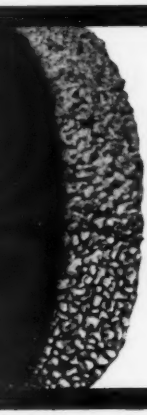

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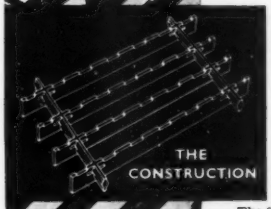

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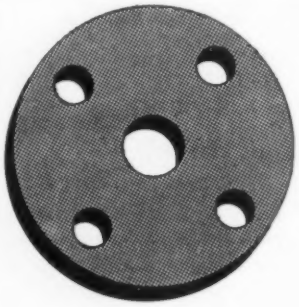

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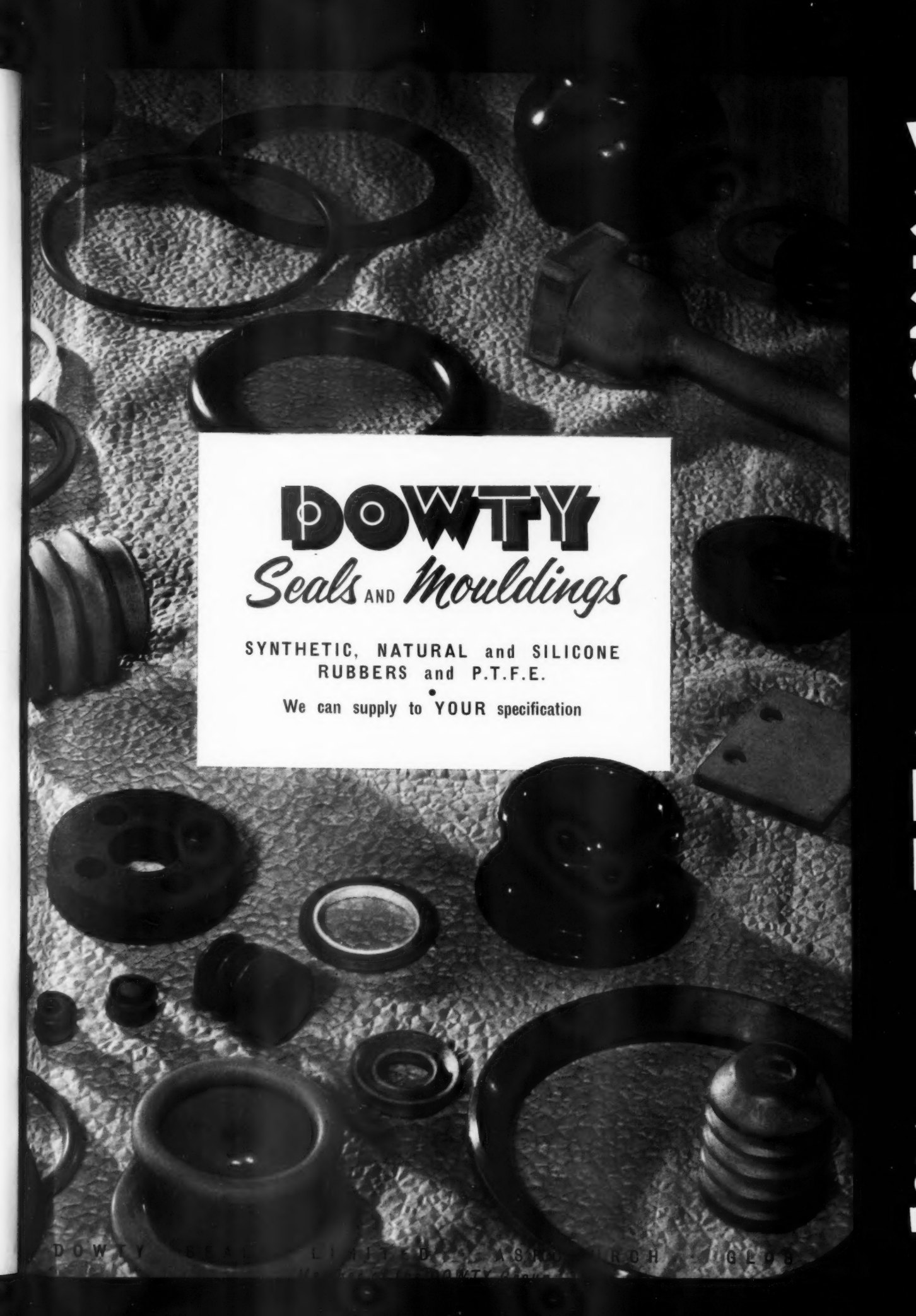
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An artist's impression of the new 360,000 kw Nuclear Power Station under construction at Hunterston

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